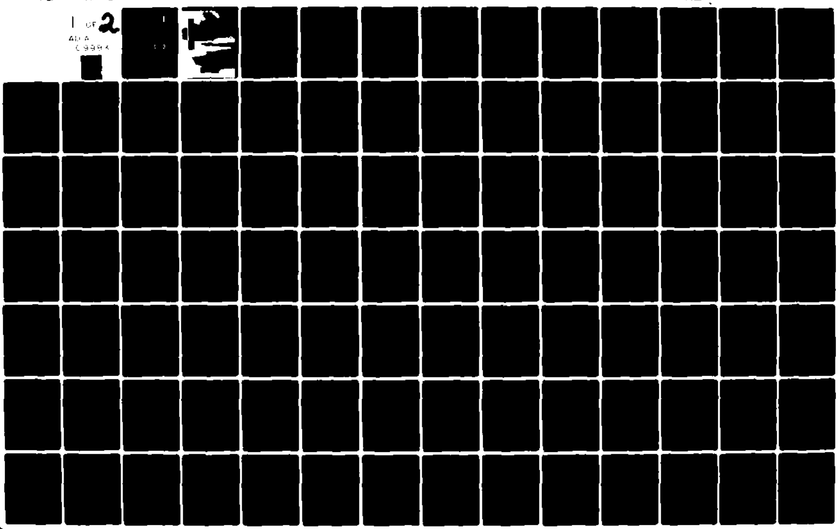
AD-A109 983 CORPS OF ENGINEERS ST PAUL MN ST PAUL DISTRICT F/G 13/2
AN ASSESSMENT OF WATER QUALITY IMPACTS OF MAINTENANCE DREDGING --ETC(U)
OCT 81 D ANDERSON, R WHITING, J NOSEK

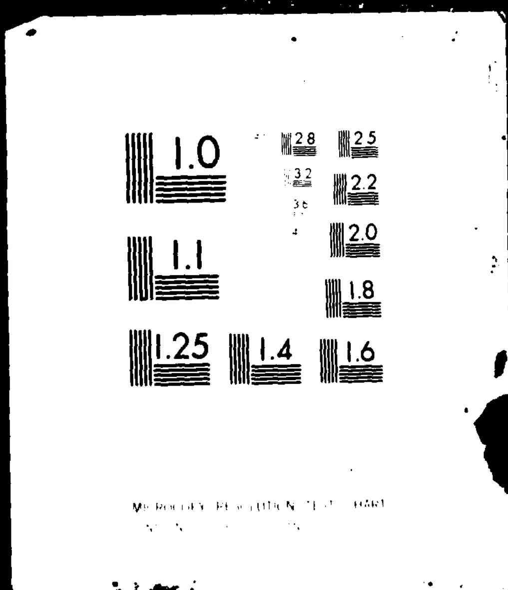
UNCLASSIFIED NL

1 OF 2
AD A
109983



1 OF 2

AD A
109983



PHOTOGRAPH THIS SHEET

ADA109983

DTIC ACCESSION NUMBER

LEVEL

INVENTORY

Army Engineer District
St. Paul, MN

An Assessment of Water Quality Impacts of Maintenance Dredging on the Upper Mississippi River in 1979 Final Rept., Oct. 81

DOCUMENT IDENTIFICATION

DISTRIBUTION STATEMENT A
Approved for public release;
Distribution Unlimited

DISTRIBUTION STATEMENT

ACCESSION FOR		
NTIS	GRA&I	X
DTIC	TAB	☐
UNANNOUNCED		☐
JUSTIFICATION		
BY		
DISTRIBUTION /		
AVAILABILITY CODES		
DIST	AVAIL AND/OR SPECIAL	
A		

DTIC COPY INSPECTED 3

DISTRIBUTION STAMP

DTIC
ELECTE
S JAN 22 1982 D
D

DATE ACCESSIONED

01 20 2 002

DATE RECEIVED IN DTIC

PHOTOGRAPH THIS SHEET AND RETURN TO DTIC-DDA-2

DTIC FORM OCT 79 70A

DOCUMENT PROCESSING SHEET

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle) AN ASSESSMENT OF WATER QUALITY IMPACTS OF MAINTENANCE DREDGING ON THE UPPER MISSISSIPPI RIVER IN 1979.	5. TYPE OF REPORT & PERIOD COVERED Final
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Dennis Anderson Robert Whiting John Nosek	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Army Engineer District, St. Paul Environmental Resources Branch 1135 USPO & Custom House, St. Paul MN 55101	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS Office, Chief of Engineers, U.S. Army Washington, D.C. 20314	12. REPORT DATE October 1981
	13. NUMBER OF PAGES 94 p.
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)	15. SECURITY CLASS. (of this report) Unclassified
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Dr. Frank Martin, University of Minnesota, performed the statistical analysis and helped set up the experimental design for the studies.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Dredging
Sediments
Water quality

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

In connection with the 1979 maintenance dredging season, the Corps of Engineers, St. Paul District investigated the water quality impacts of hydraulic and clamshell dredging operations at five selected sites on the Upper Mississippi River. Turbidity values and suspended solids were monitored at all sites, and selected chemical parameters were monitored at two hydrualic dredging sites.

At most sites, dredging amd disposal operations produced minor and localized changes in water quality. No statistically significant increases in chemical

parameters were noted due to hyraulic dredging operations. However, effluents from the dispoal area did cause some elevations of heavy metals (cadmium, lead, nickel, zinc, copper, chromium) and total ammonia. None of the chemical parameters tested exceeded their maxium permissible level proposed by Federal Water Quality Criteria.

The five monitoring studies generally indicated that rapid settling and dilution occurred near and downstream of dredging and disposal operations.

AN ASSESSMENT OF WATER QUALITY IMPACTS OF MAINTENANCE DREDGING ON THE UPPER MISSISSIPPI RIVER IN 1979

Prepared By

Dennis Anderson
Robert Whiting
John Nosek

Department of the Army
St. Paul District, Corps of Engineers
1135 U.S. Post Office and Custom House
St. Paul, Minnesota 55101

October 1981

TABLE OF CONTENTS

	Page

LIST OF FIGURES

LIST OF TABLES

AN ASSESSMENT OF WATER QUALITY IMPACTS OF
MAINTENANCE DREDGING ON THE
UPPER MISSISSIPPI RIVER IN 1979

ABSTRACT

The St. Paul District, Corps of Engineers, conducted water quality monitoring and testing in connection with the 1979 maintenance dredging season on the Upper Mississippi River. The Corps investigated the water quality impacts of hydraulic and clamshell dredging operations at five selected sites on the Upper Mississippi River. Indicator parameters (turbidity values and suspended solids) were monitored at the three hydraulic and two clamshell dredging sites. Selected chemical parameters were monitored at two of the hydraulic dredging sites. The effluent quality resulting from placement of hydraulically dredged material in all bermed on-land disposal areas used in 1979 was also monitored. In addition, a bottom sediment survey was conducted of sites in portions of the Upper Mississippi and Minnesota Rivers with a dredging frequency greater than 10 percent that were not sampled in previous years. Sediment samples were analyzed for particle size, settleability, and bulk chemistry.

Dredging and disposal operations at most of the sites investigated did produce minor and localized changes in water quality. Compared to ambient river values, turbidity and suspended solids levels increased within a localized area of the dredge and effluent pipe from the confined on-land disposal areas. Generally, the effluent from containment areas for hydraulically dredged material produced the greatest effects on water quality. At sites where observable effects occurred, the distances at which the indicator parameters approached ambient upstream control values varied with each study site (e.g., 800 feet to one mile downstream of the effluent pipe). The maximum increases in turbidity and suspended solids values compared to ambient values resulted from the discharge of effluent from a confined on-land disposal site in Pool 2. In this study, turbidity and suspended solids values were an average of 12 percent greater within a mile downstream of the containment area than upstream control values. However, the data indicated that the effects from the effluent had disappeared within one hour after the effluent stopped running.

In the two studies where selected chemical parameters were tested, no statistically significant increases in chemical parameters were noted due to hydraulic dredging operations. However, the effluents from the disposal area did cause some elevations in the chemical parameters. Higher levels of heavy metals (e.g., cadmium, lead, nickel, zinc, copper, chromium) and total ammonia were observed within 400 feet downstream of the disposal area in Pool 2. In this same study, PCB's and dieldrin were detected in the effluent from the disposal area. The other study, conducted in the lower portion of Pool 4, did not show any statistically significant increase below the effluent pipe in the selected chemical parameters analyzed. However, in this study a decrease in specific conductivity and transmissibility of the water were noted downstream of the effluent pipe. In these two studies, none of the chemical parameters tested in any of the water samples exceeded their maximum permissible level at any one time proposed by Federal Water Quality Criteria. However, some water samples that contained PCB's and heavy metals exceeded MPCA-proposed water quality standards which are comparable to the proposed 24-hour-average Federal Water Quality Criteria.

The five monitoring studies generally indicated that rapid settling and dilution occurred near and downstream of dredging and disposal operations.

Monitoring of effluent from on-land bermed confinement areas indicated that effluent quality was probably better than if unrestrained disposal methods had been used. However, it is likely that effluents from containment areas will continue to exceed applicable effluent standards for turbidity and suspended solids, given the size constraints of available disposal areas and the continued use of present disposal methods.

Bottom sediment reconnaissance of dredge sites with a dredging frequency greater than 10 percent indicated that higher levels of contaminants were closely associated with the amount of fine sediments. Boat harbor sediments were considerably higher in percentages of fine materials than main channel sites. Boat harbor sediments accounted for all pesticides detected and had high levels of COD and chemical contaminants such as arsenic, chromium, copper, and lead. Also, turbidity and suspended solids levels in settleability tests corresponded with the amount of fine material in the bottom sediments.

ACKNOWLEDGEMENT

Dr. Frank Martin from the University of Minnesota performed the statistical analysis and helped set up the experimental design for the studies. Many other St. Paul District personnel were involved in the field collection, editing, and typing of this document. We wish to express our gratitude to these people for their contributions to the study.

ERRATUM

Pp. 1-130. "Teepeota" should be "Teepeeota."

INTRODUCTION

BACKGROUND

Maintenance of a 9-foot navigation channel on the Upper Mississippi River is a Federal activity authorized by the River and Harbor Act of 1930 and other statutes. As part of this maintenance project, the St. Paul District, Corps of Engineers, performs annual maintenance dredging of the navigation channels to remove accumulated sediments which prevent safe vessel passage. Disposal of this dredged material is regulated under Section 404 of the Clean Water Act of 1977 (Public Law 92-500 ammendments) which provides authority to the States, as well as to the U.S. Environmental Protection Agency, to participate in the regulatory process. The research presented in this report is the result of an agreement between the Minnesota Pollution Control Agency and the St. Paul District, Corps of Engineers, to conduct water quality monitoring and testing in connection with the 1979 maintenance dredging season on the Upper Mississippi River. This is a continuation of the monitoring work initiated in 1978 under a similar agreement.

PREVIOUS DREDGING STUDIES ON THE UPPER MISSISSIPPI RIVER

Numerous studies are available on the water quality effects of dredging upon the Upper Mississippi, Minnesota, and St. Croix Rivers. One study conducted by the Corps of Engineers (1973) on the Minnesota River monitored turbidity changes resulting from a clamshell operation. In the study, turbidity tripled 100 feet downstream of the dredge. However, 0.8 mile downstream of the dredge, surface turbidity had returned to ambient, and bottom turbidity was returning to ambient levels.

Another study conducted in 1973 monitored a hydraulic dredging operation in Pool 8 of the Upper Mississippi River (Corps of Engineers, 1974) and reported a significant increase in turbidity, nitrate nitrogen, and nitrite nitrogen, resulting from a hydraulic dredging operation and subsequent dredged material deposition. In addition, significant numbers of sediment-bound fecal coliforms were released to the overlying water column and to downstream areas (Grimes, 1975).

However, in a study (Held, 1978) conducted in 1974 on a hydraulic dredging operation at the same site, increases in turbidity, nitrate nitrogen, nitrite nitrogen, and other chemical parameters were not observed. In addition to monitoring water chemistry, various biological (fisheries and benthos) and physical (particle size distribution) variables were measured prior to, during, and after dredging. The author concluded that the disposal activity during 1974 produced no measurable effects on any of these variables. However, the author did speculate about the reasons for the negligible impacts: the small dredging job; the dredged material that was not allowed to enter backwater areas; and the variance of the baseline data caused by annual, seasonal, and diel fluctuations.

In a cursory study, the Minnesota Pollution Control Agency (1975a) found that oil and mercury concentrations in the water column increased below a hydraulic dredging operation near Richmond Island in Pool 7. Turbidity and suspended solids levels were found to be above Minnesota State effluent standards in the disposal island runoff. PCB's were also detected in one of the samples from the disposal island runoff, indicating a potential for resuspension of PCB's from dredged sediments. However, the MPCA concluded that major degradation of the Mississippi River below the hydraulic dredging operation was not evident.

Most of the major studies of the water quality impacts of dredging and disposal upon the Upper Mississippi River have been conducted in the lower portion of Pool 2. Because of its location (immediately downstream of the Twin Cities area), this area contains sediments more contaminated than those found in most of the Mississippi River (GREAT I WQWG, 1978). Thus, in reviewing the following four studies, please note that they cannot be considered representative of the impacts on water quality for areas with less contaminated sediments.

One study conducted by the Minnesota Pollution Control Agency (1975b) in this area monitored the effects of clamshell dredging. Increases in concentrations below the clamshell dredging operation were noted for suspended solids, turbidity, 5-day biochemical oxygen demand, zinc, and iron. Suspended solids, turbidity, and zinc returned to background levels within one-quarter mile downstream, but BOD_5 and iron concentrations had not returned to background within 1 mile below the operation.

Another study also monitored a clamshell dredging operation in the lower portion of Pool 2, at Boulanger Bend (GREAT I, WQWG, 1980b). In this study, water quality impacts were greater in the disposal plume than in the dredge plume and greater near the bottom than near the surface. In some plume samples, proposed MPCA water quality standards were exceeded for iron, mercury, ammonia, turbidity, dissolved oxygen, and fecal coliforms; but, in almost all cases, ambient levels of these parameters were already in excess of standards.

Turbidity levels had returned to background within 1,000 feet downstream of the dredge and disposal site. Relatively poor correlations between bottom and surface concentrations of parameters were observed in this study, and between physical (turbidity and suspended solids) and biological-chemical parameters. In the Boulanger Bend study, the use of color and color infrared photography as a monitoring technique was also explored. The study showed that this technique was effective in determining the areal extent of surface turbidity plumes, although it could not predict water column impacts since relatively poor correlations were found between bottom and surface concentrations of parameters.

Another study conducted in Lower Pool 2 (in conjunction with the GREAT I (1976a) monitoring study at Grey Cloud Slough) monitored a hydraulic dredging operation (Lee, 1977). A major emphasis of this study was to field test the predictability of the elutriate test on release of contaminants from sediments. In general, metal concentrations in the disposal discharge were comparable to those obtained from elutriate tests. However, nitrogen and phosphorus compounds generally were not comparable. In the field study, increased concentrations in the disposal plume were noted for soluble iron, manganese, nickel, and zinc. In addition, aldrin, pp'DDE, op'DDE, and PCB's were detected in water samples taken directly from the discharge point. This study also showed that turbidity had returned to background levels within several hundred meters of the disposal.

For the same study, acute toxicity (96-hour) bioassays were conducted on Daphnia magna, using elutriate and dredge discharge waters. In both the elutriate and dredge discharge waters, contaminants were found not to be released in quantities sufficient to be adverse to Daphnia magna.

The GREAT I WQWG conducted a study on hydraulic dredging and disposal (beach) nourishment) near Grey Cloud Island in Pool 2 (GREAT I 1978a). During this study, turbidity and suspended solids returned to background levels within 1 mile downstream of the disposal island. Chemical and microbiological parameters closely correlated with turbidity and suspended solids, and generally returned to background levels within a short distance from the disposal runoff. Most parameters increased in concentration from above to below the dredging and disposal operations, but ambient fluctuations in the river water were, in many cases, greater than fluctuations caused by dredging and disposal. Proposed Minnesota Pollution Control Agency water quality standards for arsenic, chromium, lead, mercury, manganese, PCB's, and suspended solids were exceeded only in a limited area immediately downstream of the disposal runoff.

Cursory examinations of methods for minimizing disposal impacts from hydraulic dredging operations were performed by Claflin (1976). The use of polymer injection and silt screen were found to have only limited success in a riverine application.

A study conducted in 1977 (Marking and Bills, 1977) was aimed at assessing the acute effects of burial upon three species of freshwater mussels by dredged sediments. Two of the species studied required burial by 7 inches or more of sand or silt to prevent the emergence of 50 percent of the test populations. For the other species, pig-toe (Fusconaia flava), 4 inches of silt prevented the emergence of 50 percent of the test population. It should be noted, however, that the study only assessed the acute effects of single dredged material overlays on clams, not the effects of rates of deposit, adaption to new substrates, migration to new substrates, or long-term effects on the survival of clam populations.

In 1978, the St. Paul District, Corps of Engineers, monitored five dredging operations at various locations on the Upper Mississippi River, including three hydraulic dredging operations and two mechanical (clamshell) dredging operations (Anderson et al., 1979). Four of the studies (two for mechanical and two for hydraulic dredging) monitored only the indicator parameters (turbidity and suspended solids). The other study monitored the physical, chemical, and microbiological changes in water quality resulting from a hydraulic dredging operation. In these studies, disposal of the dredged material occurred on land. For the mechanical (clamshell) dredging, on-land disposal involved direct unloading from barges and therefore only the clamshell (dredging activity) was monitored. For the hydraulic dredging operation, the dredged material was disposed into a confined on-land disposal area with a drop structure and culverts to allow the effluent to return to the river after a short retention time. Therefore, both the hydraulic cutterhead and the effluent from the confined on-land disposal area were monitored. All five of the studies were conducted in areas with relatively coarse sediments (less than 10 percent silts and clays).

In the four turbidity and suspended solids monitoring studies, no changes or only minor changes in water quality were found to result from either the hydraulic or clamshell dredging activity. The study that monitored the effluents from a confined on-land disposal area indicated slight elevations in turbidity and suspended solids but noted that these levels had returned to ambient within 1,000 feet downstream of the disposal area.

In the study which also monitored chemical and microbiological parameters, no significant increases below the hydraulic cutterhead were evidenced for any of the physical, chemical, or microbiological parameters investigated. The effluent from the confined on-land disposal area contained concentrations of some parameters (especially iron, manganese, and the physical parameters) that exceeded the pre-dredging and upstream control values. However, only iron and manganese were found to be significantly higher downstream of the disposal pipe than in upstream control values. Daily fluctuations in concentrations for most of the parameters were fairly substantial and tended to mask any impacts caused by dredging.

The authors concluded that with the methods used for disposal of the dredged material at the five sites studied, no major degradation of water quality was evidenced for either the mechanical (clamshell) or hydraulic dredging operations.

In 1978, a bottom sediment reconnaissance was conducted by the Corps of Engineers for many historical dredging sites on the Upper Mississippi River. In the study, sediment samples were analyzed for bulk chemistry, particle size distribution, and settleability. The study indicated that the location on the river and the amount of fine materials (silts and clays) strongly influenced contaminant levels within the main channel of the river. Frequency of dredging at a site was not a major factor in determining the degree of contamination. Sites in and immediately downstream of the Twin Cities metropolitan area contained the most contaminated sediments. High levels of contaminants were closely associated with the finer sediments. Most of the sediments samples in this study were coarse, with 85 percent of the sites having less than 10 percent silts and clays and most having less than 4 percent.

The bioaccumulation potential of PCB's and selected heavy metals and the acute toxicity of sediments from three test sites and one reference site on the Upper Mississippi River were investigated in 1979 (Peddicord et al., 1979). In this study, water fleas (Daphnia), catfish, and bluegills were exposed to suspensions of fine-grained sediment from three test sites and one reference site for 4 to 6 days, approximately the duration of a typical dredging and disposal operation on the Upper Mississippi River. Survival and tissue concentrations of contaminants in fish were determined after exposure. Fawnfoot and three-ridge clams, mayfly larvae, and amphipods were exposed to deposited sediments for up to 14 days, after which survival and contaminant concentrations in tissues of clams were determined.

All three test sediments were of low toxicity to all species except the amphipods, in that no sediment produced statistically greater mortality than occurred in the controls and reference sediment. Although statistical comparisons were not made, amphipod mortality in some UMR sediments apparently exceeded that in the controls, but probably not that in the reference sediment. Bioaccumulation was the exception, rather than the rule, with 72 species-sediment-contaminant combinations being studied and bioaccumulation potential being indicated in eight (11 percent) of the cases. Even in these cases, resulting concentrations were below those considered likely to cause adverse impacts. The study, although not definitive, provided little reason to suspect serious toxicity or bioaccumulation from the sediments investigated.

OBJECTIVE OF THE 1979 MONITORING PLAN

The overall objective of the 1979 monitoring plan was to expand the information available on the water quality impacts of dredging and disposal operations on the Upper Mississippi River. The data collected in 1978 and 1979 will be used for short-range river management and will provide additional information for the development of long-range planning and establishment of applicable dredging standards.

In 1979, five dredging and disposal operations were monitored to assess the impacts on water quality. Three of the studies monitored hydraulic dredging operations and effluents from confined on-land disposal areas. The other two studies monitored clamshell dredging operations. Turbidity and suspended solids, shown by a previous study to be useful indicators of physical, chemical, and microbiological impacts (GREAT I WQWG, 1978) were monitored in all five dredging operations. In addition, selected chemical parameters were monitored for two of the hydraulic dredging and disposal operations. The effluents generated from all confined on-land disposal areas used in 1979 were monitored to assess the potential impacts on water quality.

In addition to monitoring water quality impacts of dredging and disposal operations, sediment studies were conducted in 1979 to assess potential impacts of maintenance dredging on the Upper Mississippi River. The major objective of the 1979 monitoring was to gain site-specific information on dredging sites having a dredging frequency greater than 10 percent and for which little or no sediment information exists. For this survey, sediment samples were analyzed for bulk chemical constituents, particle size, and settleability.

The last portion of the 1979 monitoring program initiated the use of sediment bioassays to assess the acute toxic effect of ten sediment types from the Upper Mississippi, St. Croix, and Minnesota Rivers on a variety of endemic species. This portion was completed in 1980.

OVERALL SUMMARY

The water quality impacts of dredging and disposal operations were investigated by the St. Paul District, Corps of Engineers, at five selected sites on the Upper Mississippi River. Three of the five studies monitored hydraulic dredging operations and effluents from confined on-land disposal areas. The other two studies monitored clamshell dredging operations.

Indicator parameters (turbidity and suspended solids) were monitored in all five dredging operations. In addition, selected chemical parameters were monitored for two of the hydraulic dredging and disposal operations. The effluents from all confined on-land disposal areas used in 1979 were monitored and evaluated for (1) potential water quality impacts and (2) the efficacy of pond areas in reducing the water quality impacts of the disposal of hydraulically dredged material. Finally, a bottom sediment study of dredge sites with a dredging frequency greater than 10 percent and not sampled in previous years was conducted for the navigational portions of the Upper Mississippi and Minnesota Rivers. The sediment samples were analyzed for bulk chemistry, particle size, and settleability.

The water quality effects of hydraulic dredging and of the effluents from the confined on-land disposal areas were monitored at three sites: the St. Paul Barge Terminal Dredge Site (Cairo mile 837), the Teepeota Dredge Site (Cairo mile 757.5), and the Below West Newton Dredge Site (Cairo mile 746.6). Observed changes in water quality at all three sites resulted mainly from the effluents from the disposal area. Only at one site, Below West Newton, were there any observable changes in the indicator parameters (turbidity and suspended solids) as a result of the hydraulic dredge. However, at all three sites there appeared to be at least some changes in the indicator parameters as a result of the effluent from the disposal areas. At the three sites, turbidity and suspended solids levels were higher in the effluent than in their respective ambient upstream control levels. Increased levels of turbidity downstream of the disposal areas compared to upstream control values were statistically significant at the Below West Newton and St. Paul Barge sites, but not at the Teepeota Point site. Increased levels of suspended solids downstream of the disposal area compared to upstream control levels were statistically significant at the St. Paul Barge site only.

At each of the three hydraulic dredge sites, the water quality effects due to effluent from the on-land disposal areas were relatively minor. The distance at which increased turbidity and suspended solids levels approached ambient control values varied with each study site. Turbidity values in excess of upstream controls occurred within 800', 1600' and one mile downstream of the effluent pipe at the Below West Newton, Teepeota, and St. Paul Barge sites, respectively. Suspended solids values were higher than control values 800 feet downstream of the effluent disposal pipe at the Teepeota and St. Paul Barge sites. Suspended solids values downstream of the pipe were not elevated compared to ambient values at the Below West Newton dredge site. Ambient values at the Below West Newton site were high (10 times greater than ambient values recorded within 10 miles of the site eight days earlier), and may have masked the effects of dredging and disposal operations at this site.

Of the three studies conducted, the St. Paul Barge Terminal disposal operation produced the greatest changes in the indicator parameters (turbidity and suspended solids). Within the one-mile study area below the disposal area at the St. Paul Barge Terminal, a 12-percent average increase in turbidity and suspended solids over upstream control occurred. However, it was noted that the effects from the disposal area had disappeared within one hour after the effluent stopped running from the pipe.

In addition to monitoring changes in turbidity and suspended solids levels, selected chemical and other physical parameters were monitored at two of the hydraulically dredged sites. No statistically significant increases in chemical parameters due to dredging operations were noted in either study. However, effluent from on-land disposal areas did cause localized changes in water quality at the two study sites. At the St. Paul Barge Terminal site, cadmium, lead, zinc, and total ammonia concentrations were two to six times greater in the effluent than in upstream controls. Chromium levels in the effluent were only slightly higher than upstream controls. Increased concentrations of these parameters were noted within 400 feet downstream of the effluent pipe. However, the concentrations of these parameters had returned to near-ambient levels 400 feet downstream of the effluent pipe, and were at ambient levels within 2,700 feet of the disposal area.

Polychlorinated biphenyls (PCB's) and selected biocides were also monitored at the St. Paul Barge Terminal. PCB's and dieldrin were the only parameters that had detectable levels in any of the samples collected. PCB's were detected in two samples, one taken directly from the effluent pipe and another sample taken 100 feet downstream of the effluent pipe. Dieldrin was only detected in the effluent from the disposal area.

At the Teepeota Point dredge site, the effluent had no apparent effect on pH or levels of cadmium, chromium, nickel or zinc in the Mississippi River water. However, copper, lead, total ammonia, and temperature, although not statistically significant, appeared to have increased slightly immediately downstream of the disposal area.

At the Teepeota site, a significant positive regression of specific conductance with distance downstream of the effluent pipe was noted. Decreased specific conductance levels gradually returned to ambient levels within 3,200 feet downstream of the disposal area.

Results from an in situ recording transmissometer indicated the hydraulic dredge had little effect on the transmission of light in the river water. However, light transmission was decreased within 800 feet downstream of the effluent pipe. It was also noted that hydraulic factors may greatly influence the return to background levels and the configuration of the plume.

In situ toxicity exposure tests on fathead minnows (Pimephales sp.) conducted at the Teepeota site were unsuccessful due to mortality in upstream controls. Mortality was probably due to stress from high current velocities.

At both the St. Paul Barge Terminal and Teepeota Point, none of the chemical parameters exceeded the proposed Federal Water Quality Criteria for maximum permissible levels. However, some water samples that contained PCB's, biocides, and heavy metals exceeded MPCA proposed water quality standards, which are comparable to the proposed 24-hour-average Federal Water Quality Criteria. Most samples which had levels for a given parameter exceeding their respective proposed 24-hour-average criteria were from the effluent and within 200 feet of the disposal area. The data indicate that rapid settling and dilution occurred near and within a localized area downstream of dredging and disposal operations.

The water quality effects of clamshell dredging at the two sites studied in 1979, Above Lake Street (Cairo mile 850.3) and Island 58 (Cairo mile 734.3), were similar to those observed in the hydraulic dredging studies. At the Above Lake Street site, turbidity and suspended solids levels were elevated compared to control values an average of 0.5 NTU and 10 mg/l, respectively. However, values 800 feet downstream of the dredge were comparable to ambient upstream controls. No significant increases in turbidity or suspended solids due to clamshell dredging occurred at the Island 58 site. It is unlikely that any major degradation of water quality occurred at either site.

In addition to monitoring the water quality impacts of dredging and disposal operations, the effluent quality from seven bermed, on-land confinement areas was compared. The levels of turbidity, suspended solids, specific conductance, and pH were monitored in water samples collected from the effluent pipe at each of the seven hydraulically dredged sites in 1979.

Effluents from Read's Landing (Cairo mile 762.6), Fisher Island (Cairo mile 745.7), Mule Bend (Cairo mile 749.1), and Teepeota Point (Cairo mile 757.6) disposal areas were similar in quality. Mean suspended solids and turbidity values in the effluents from these four sites ranged from 60 to 64 mg/l and 28 to 32 NTU, respectively. The effluents from the Below West Newton (Cairo mile 746.6) and St. Paul Barge Terminal (Cairo mile 837) sites were of lower quality than the other sites. The Below West Newton site had mean turbidity and suspended solids values in the effluent of 633 NTU and 1,271 mg/l, respectively. Two dredge cuts were dredged at the St. Paul Barge Terminal in 1979. Effluents generated when the first dredge cut was dredged had mean turbidity and suspended solids values of 109 NTU and 316 mg/l, respectively. Effluents generated when the second dredge cut was dredged had mean turbidity and suspended solids values of 1,027 NTU and 33,456 mg/l, respectively. Turbidity and suspended solids exceeded Minnesota State effluent standards in all samples collected (25 NTU and 30 mg/l, respectively).

Specific conductance mean values ranged from 334 at Read's Landing to 811 from the second dredge cut at the St. Paul Barge Terminal. Data on specific conductivity was not obtained at two of the dredge sites (Crats Island and Below West Newton). Values for pH in all effluent samples collected from the various disposal areas were within the range of applicable Minnesota State effluent standards.

Results indicated that bermed containment areas probably improved effluent quality compared to the use of unrestrained disposal alternatives. However, it is likely that effluents from containment areas will continue to exceed applicable effluent standards for turbidity and suspended solids, given the size constraints of available disposal areas and the continued use of present disposal methods.

The 1979 bottom sediment reconnaissance for portions of the Upper Mississippi and Minnesota Rivers indicated that contaminant levels were associated with the amount of fine materials in the bottom sediment. Particle size analysis indicated that sediment samples from the main channel areas were composed of coarse material. Boat harbor sediments were considerably higher in percentages of fine material.

Boat harbor sediments accounted for all pesticides detected and had high levels of several chemical contaminants. Higher levels of PCB's (13 to 82 ug/kg) were detected in boat harbor sediments than in main channel sediments, which did not exceed 3 ug/kg.

Concentrations of arsenic (6 ug/g), chromium (>10 ug/g), copper (30 ug/g), and lead (>10 ug/g) were found more commonly in boat harbors than in main channel sites. Barium, iron, manganese, nickel, and zinc concentrations were found in all samples. However, these are naturally occurring metals and are abundant in the environment.

High COD levels (>20,000 mg/l) were also associated with high concentrations of fine materials. Sites which did not have high percentages of fine material had less than 10,000 mg/kg; the majority were below 4,000 mg/kg COD.

Also, initial high turbidity and suspended solids levels in the settleability tests corresponded with the amount of fine materials in bottom sediments. Turbidity levels greater than 1,200 FTU and suspended solids levels greater than 40,000 mg/l were found in sediments with 9 percent and 25 percent fine material.

ST. PAUL BARGE TERMINAL (CAIRO MILE 837) MONITORING OF CHANGES IN PHYSICAL AND CHEMICAL PARAMETERS RESULTING FROM HYDRAULIC DREDGING AND EFFLUENT FROM CONFINED ON-LAND DISPOSAL

OBJECTIVE

The objective of the study was to determine the areal extent of turbidity and suspended solids changes and to monitor the levels of several chemical parameters resulting from a WILLIAM A. THOMPSON hydraulic dredging operation and the effluent from confined on-land disposal of the dredged material.

METHODS

DESCRIPTION OF SAMPLING SITES

The St. Paul Barge Terminal dredge cut area is located between Cairo mile 837.1 and 837.6. The area is adjacent to the Downtown St. Paul Airport and is located on the inside of a bend. Shoaling occurs in this area because of the bend, requiring maintenance dredging at an annual frequency of 52 percent. The average volume dredged per job is 139,800 cubic yards.

During 1979, two cuts were dredged to a depth of 13 feet below low-control pool with the 20-inch hydraulic dredge WILLIAM A. THOMPSON, removing 159,000 cubic yards of accumulated sediment. Disposal of the material occurred in a bermed disposal area located on the right descending bank at Cairo mile 838.0. The area had an inside capacity of 6.8 acres. A drop structure allowed for the return of effluent after a short retention time. Beneficial use was designated for this site: the material was to be used by the St. Paul Port Authority as fill material. Dredging was conducted at this site from 12 July 1979 to 6 August 1979.

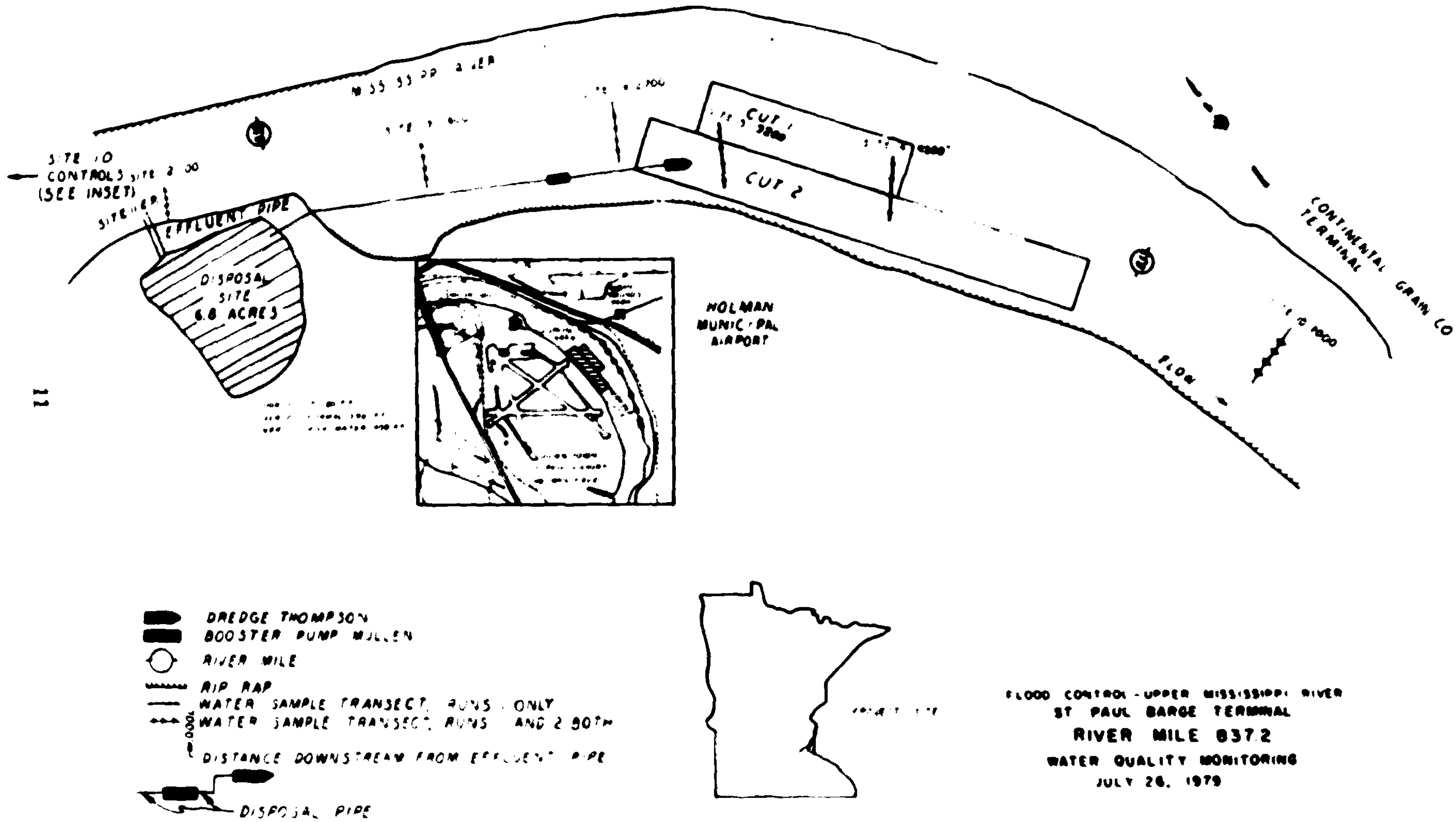
EXPERIMENTAL DESIGN

Sediment. Prior to dredging operations on 25 July 1979, four sediment samples were collected with a Ponar bottom sampler from the area to be dredged. Serco, Inc., of Roseville, Minnesota, did the sediment collection and performed particle size and settleability analyses on these samples.

Water. Prior to dredging, 10 background water samples were collected from the proposed dredge area, to be analyzed for turbidity and suspended solids. Samples were collected on 3 July, 5 July, 6 July, 10 July, and 16 July 1979. In addition, 10 post-dredging water samples were collected on 13 August, 7 days after dredging was completed at this site, and analyzed for turbidity and suspended solids.

The water quality monitoring of the dredging operation at the St. Paul Barge Terminal was done in two phases. Phase I (26 July 1979) assessed the general magnitude of water quality changes (as defined by turbidity and suspended solids levels) within a 1-mile reach of the river downstream of the outfall from the confined on-land disposal area. In phase I (see Figure 1) 46 water samples were collected in two runs to be analyzed for turbidity and effluent solids. In run 1, samples were taken at upstream control sites; the effluent pipe; at 100,

Figure 1. St. Paul Barge Terminal Dredge Site on the Upper Mississippi River: Sampling Site Locations for Phase I (July 26, 1979).



1,600 and 2,700 feet below the effluent pipe; at sites near the dredge cutterhead (4,200 feet downstream of effluent pipe); and at sites 1,000 and 2,800 feet (5,200 and 7,000 feet below the effluent pipe, respectively) below the dredge. In run 2, water samples were collected only at the last four sites listed above. Run 2 occurred 1 hour after the effluent pipe from the confined on-land disposal area had stopped running, and was aimed at assessing the effects on water quality due only to the hydraulic cutterhead.

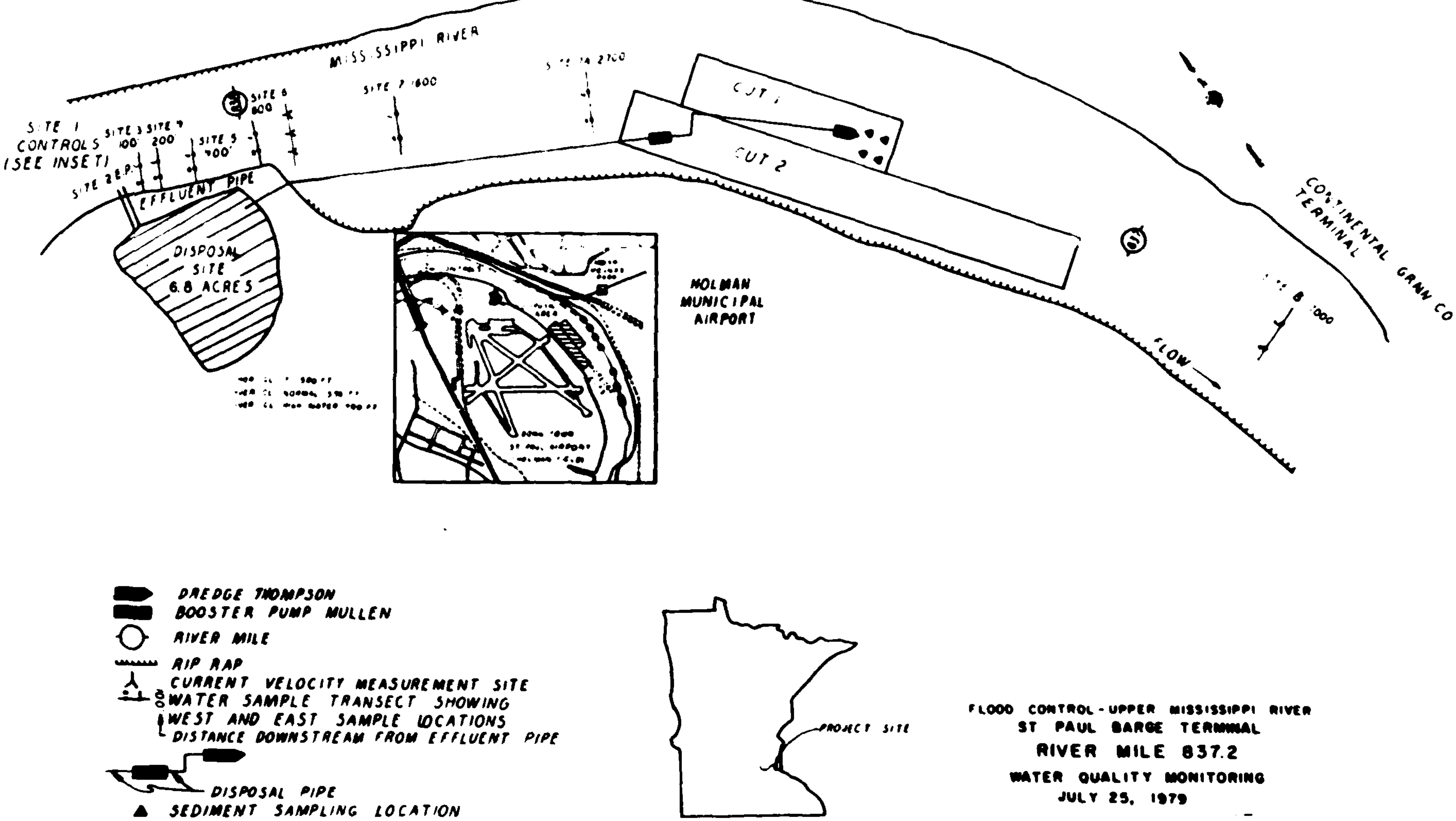
In phase II of the water quality monitoring (25 July 1979), 24 water samples were collected to be analyzed for total ammonia, cadmium, chromium, copper, lead, nickel, zinc, turbidity, suspended solids, pesticides, and PCB's. Samples were taken from control sites; the effluent pipe; and sites 100, 200, 400, 800, 1,600, 2,700, and 7,000 feet below the effluent pipe (see Figure 2). All sites except the 7,000-foot sites were upstream of the dredge.

All water samples were discrete samples, collected 3 feet from the bottom. Samples were collected near the bottom, because previous studies indicated that the greatest impacts on water quality usually occur in the lower portion of the water column (Anderson et al., 1979; GREAT I WQWG, 1976; GREAT I WQWG, 1979). Either a PVC or nickel-plated Van Dohrn type water sampler was used, depending upon the parameter being tested for each sample.

Pre-dredging background samples were analyzed by USGS. Serco, Inc., of Roseville, Minnesota, conducted all turbidity and suspended solids determinations for phase I, phase II, and post-dredging. All chemical parameters of phase I were determined by USGS.

Analytical Methods. Samples were chilled after collection and shipped as soon as possible for laboratory analysis. Collection and analysis of turbidity and suspended solids samples followed guidelines set forth in the U.S. Environmental Protection Agency's "Methods for Chemical Analysis of Water and Wastes," July 1974. Particle size analysis of sediment samples was accomplished by use of standard mesh screens and a hydrometer for the finer particles. Settleability was conducted according to Anderson et al., 1979. Chemical analyses of water samples done by the U.S. Geological Survey Laboratory in Atlanta, Georgia, were conducted according to Skougstad et al., 1979, and Goerlitz and Brown, 1972.

Figure 2 - St. Paul Barge Terminal Dredge Site on the Upper Mississippi River: Sampling Site Locations for Phase II.



RESULTS

FIELD CONDITIONS

Weather conditions during the sampling on 25 and 26 July 1979 were sunny to partly cloudy and hot, with a high temperature near 90°F. Barge traffic was almost continuous during both days of sampling.

River-stage readings from Lock and Dam No. 2 near Hastings, Minnesota, were relatively high for this time of year (86.70). Velocity measurements taken on 25 July 1979 indicated that water was moving slightly faster near the surface than near the bottom. A mean velocity of 1.4 feet/second occurred 3 feet from the surface, compared with a mean velocity of 1.0 feet/second 3 feet from the bottom.

SEDIMENTS

Particle Size. The dredged sediments ranged from fine- to medium-grained sand to silty sand (Appendix Table A1). The percentage of silts and clays ranged from 2 to 6 percent in the four sediment samples. The amount of silts and clays from the dredge cut being dredged fell between the values for the coarsest and finest sediments in the area of the historical dredge cut at the St. Paul Barge Terminal which was sampled in 1978 (Anderson et al., 1979).

Settleability. The settleability tests indicated a fairly large turbidity and suspended solids generation potential for the sediments. Initial concentrations after agitation for suspended solids were 3,790 and 10,230 mg/l in the two sediment samples tested (Appendix Table A3). Initial turbidity values were 300 and 400 NTU for the two sediment samples (Appendix A2). At the end of 8 hours, suspended solids had a mean concentration of 22 mg/l. Turbidity was still elevated at the end of 8 hours, with a mean value of 62.5 NTU. Turbidity showed a less steep drop in values than did suspended solids. In a 1978 sediment monitoring study of the Upper Mississippi River, 85 percent of the sediment samples had lower initial values than did the samples from the St. Paul Barge Terminal (Anderson et al., 1979). However, like the particle size, the values recorded in the study fell between the values recorded for the finest and coarsest sediments within the entire historical dredge cut that was sampled in 1978 (Anderson et al., 1979).

Bulk Chemistry. Although the bottom sediments were not analyzed for bulk chemical constituents in this study, a previous study indicated that bottom sediments in this area range from moderately contaminated to heavily contaminated when compared with other areas on the Upper Mississippi River (Anderson et al., 1979).

WATER QUALITY

Background. A comparison of pre- and post-dredging and upstream control samples for the 2 days of sampling indicates that substantially higher concentrations of turbidity and suspended solids occurred on the 2 days the dredging operation was monitored than in predredging samples (Appendix Tables A4-A6). Post-dredging samples were also higher than pre-dredging buc slightly lower than on the 2 days of dredging (Appendix Table A5). This would indicate that fluctuations in turbidity and suspended solids within this reach are fairly substantial. Owing to the long time lapse between collection of pre-dredging and post-dredging samples (almost 1½ months), this phenomenon is probably attributable to seasonal fluctuations in the suspended material transport along this stretch of the river.

Phase I. The purpose of phase I was to assess the general magnitude of changes in water quality (turbidity and suspended solids) within a 1-mile reach of the river below the effluent pipe, resulting from both the use of the hydraulic cutterhead and the effluents from the confined on-land disposal area. In phase I, turbidity and suspended solids values in all river water samples ranged from 28 to 93 NTU and 64 to 563 mg/l, respectively (Appendix Table A6). Turbidity and suspended solids data from this phase correlated very well, having a correlation coefficient of 0.92.

Both turbidity and suspended solids in run 1 showed significant increases (t-test) below the effluent pipe compared to upstream controls. The mean turbidity of the upstream control samples was 50.7 NTU compared to a mean of 56.7 NTU below the effluent pipe (Table 1). The mean suspended solids concentration in upstream control samples was 170.5 mg/l compared to a mean concentration of 214 mg/l downstream of the effluent pipe. Approximately a 12-percent increase in turbidity and suspended solids occurred below the effluent pipe in run 1.

Table 1. Mean Concentrations of Turbidity and Suspended Solids in Controls, Run 1 Downstream of Effluent Pipe, and Run 2 Downstream of the Cutterhead.

	Turbidity (NTU) (mean (standard error))	Suspended Solids mg/l (mean (standard error))
Controls	50.7 (16.99)	170.5 (92)
Run 1	56.7*(17.6)	214*(112)
Run 2	49.5 (8.2)	158 (38.5)

*Significantly different α =.05

The large standard sampling error, especially for suspended solids, indicates substantial fluctuations in values, both in ambient water and downstream of the effluent pipe water. Part of this may be due to the high barge traffic in this area.

Run 2 in this phase was made approximately 1 hour after the effluent pipe stopped running, and focused on assessing the effects of the hydraulic cutterhead (Appendix Table A6). In run 2, the mean values for turbidity and suspended solids were 49.5 NTU and 158 mg/l, respectively (Table 1). These values were generally comparable to the mean upstream control values from run 1, indicating that the hydraulic cutterhead had very little, if any, effect on turbidity and suspended solids. This contention is supported by the lack of any observable increases in values for the transect (Location 15) immediately downstream of the dredge compared to the values for the transect (Location 14) immediately upstream of the dredge (Figure 1, Appendix Table A6). The run 2 data also suggest that the effects from the effluent pipe disappeared within 1 hour after the effluent pipe stopped running.

No obvious relationship to distance below the effluent pipe was evidenced in this phase. The coefficient of determinations, which examines the variance in values caused by distances, was very low (r^2 = .05 for turbidity and r^2 = .01 for suspended solids). These results may have been caused by the fact that only one elevated value out of four was found at Location 12 (100 feet from the effluent pipe) and the plume may have been missed by some of the sampling sites on the 100-foot transect (Appendix Table A6). In addition, the large fluctuations tended to mask any trends with distance.

Phase II. The effluent quality between the two phases of sampling varied considerably. The samples collected from the effluent for phase II on 25 July 1980 had mean turbidity and suspended solids values of 200 NTU's and 867 mg/l, respectively (Appendix Table A7). Samples collected for phase I on 26 July 1980 had a mean turbidity value of 20,000 NTU's and a mean suspended solids concentration of 210,000 mg/l (Appendix Table A6). This makes a comparison of water quality effects between the two days of sampling extremely difficult. However, it is interesting to note that the turbidity and suspended solids values of samples collected within 100 feet of the effluent pipe in phase II were not substantially different from those in phase I (Appendix Tables A6 and A7). In phase II biocides and polychlorinated biphenyls were below their respective detection limits in almost all samples collected. PCB's were detected near the limits of sensitivity at 0.1 ug/l in two samples (Appendix Table A7). One of the samples was from the effluent pipe, the other from 100 feet downstream of the effluent pipe. The remaining samples from phase I were reported a 0.0 ug/l (maximum sensitivity of 0.05 ug/l). The biocides that were analyzed included: aldrin, chlordane, DDD, DDE, DDT, dieldrin, endosulfan, endrin, heptachlor epoxide, heptachlor, lindane, mirex, polychlorinated naphthalenes (PCN), perthane, and toxaphene. Of these only dieldrin was detected in any of the water samples, i.e., one sample at 0.01 ug/l collected from the effluent pipe.

A comparison of effluent pipe samples with upstream control samples indicates that copper, lead, nickel, ammonia nitrogen, zinc, turbidity, and suspended solids concentrations were from 2 to 6 times greater in the effluent pipe than in upstream control samples (Appendix Table A7). Chromium showed less reaction, being only slightly elevated over control values in the effluent. Because of the large number of samples reported as having zero concentrations, the cadmium data is difficult to interpret and therefore was not included in any of the statistical analyses. However, cadmium showed no elevation in the water column caused by the effluent pipe.

Means for all of the parameters were calculated for each of the distances from the effluent pipe. Samples 3E and 4E from Appendix Table A7 were not used in the calculation of means because these samples, although collected within 100 feet of the shore, had apparently missed the plume. Correlation analysis was then run on these mean values (Table 2). Copper, lead, nickel, ammonia nitrogen, zinc, turbidity, and suspended solids correlated positively with each other. Chromium did not correlate well with the other parameters, except with zinc. The fact that chromium did not show the elevation over controls in the effluent pipe that the other parameters did may partially explain the poor correlations to the other parameters that were observed.

Table 2. Correlation Matrix of the Chemical and Physical Parameters From Phase II of the St. Paul Barge Terminal Study

	Chromium	Copper	Lead	Nickel	NH_4 as N	Zinc	Turbidity	Suspended Solids
Chromium	1.000							
Copper	.5229	1.000						
Lead	.6467	.9564	1.000					
Nickel	.4840	.9035	.9365	1.000				
NH_4 as N	.4475	.9929	.9456	.9218	1.000			
Zinc	.7122	.9392	.9395	.8146	.9138	1.000		
Turbidity	.4867	.9851	.9561	.9226	.9868	.9179	1.000	
Suspended Solids	.4744	.9907	.9485	.9125	.9908	.9175	.9984	1.000

Since all the parameters except chromium (which did not show much elevation) correlated will with each other, only a plot of the log of mean lead concentrations versus distance was illustrated to show the trend with distance exhibited by all the parameters (Figure 3).

Figure 3 indicates that relatively high concentrations occurred within 200 feet of the effluent pipe. However, by 400 feet a rapid drop in concentration had occurred and with increasing distance downstream of the effluent pipe, a leveling-off or slight decline occurred. By 2,700 feet, most of the parameters had returned to ambient levels; some returned sooner. Comparison of the mean values for the controls with mean values 7,000 feet below the effluent pipe, for each of the parameters, shows them to be basically the same (Table 3). This indicates that the impacts on water quality were very localized.

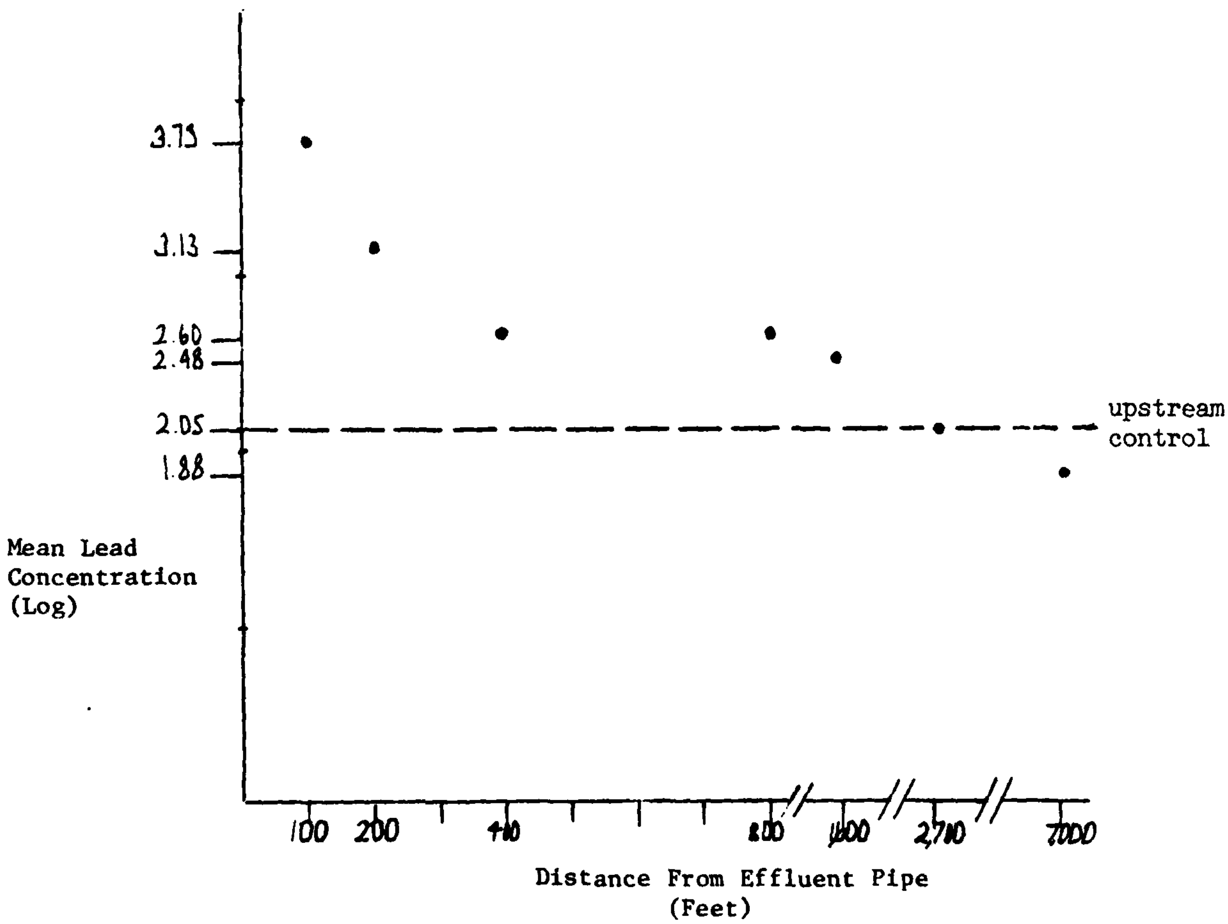
Table 3. General Comparison of Mean Concentrations of the Control Transect to 7,000 Feet Below the Effluent Pipe Transect for the Various Parameters Analyzed.

	Parameter*							
	Chromium	Copper	Lead	Nickel	NH_3& NH_4 (mg/l)	Zinc	Turbidity(NTU)	Suspended Solids (mg/l)
Control Transect	13	6	8	8	.03	30	50	165
7,000-foot Transect	13	5	7	11	.06	28	52	161

*All values in ug/l unless otherwise indicated.

FIGURE 3

Comparison of the Logarithm of Mean Lead Concentrations
Versus Distance Downstream of the Effluent Pipe
at the St. Paul Barge Terminal Dredge Site



Comparison With Water Quality Criteria and Standards. In the proposed update of the Redbook, the Environmental Protection Agency has developed sets of two numerical criteria for each of the parameters on the toxic substance list. These two criteria are a maximum permissible level at any one time and a 24-hour average level. None of the chemical parameters exceeded the proposed Federal water quality criteria for the maximum permissible levels at any one time (Table 4). However, where sufficient sensitivity in the analyses was achieved for comparison with the criteria, PCB's, dieldrin, zinc, cadmium, and copper were the only parameters found to exceed their respective 24-hour average criteria level. It should be noted that since the monitoring did not occur over a 24-hour period, a 24-hour average concentration cannot be calculated, making this comparison somewhat tenuous. It is only an indication of a potential area of concern.

PCB's, dieldrin, and zinc values exceeding the 24-hour average criteria level were found only in samples from the effluent pipe and within 200 feet of the effluent pipe. Copper values exceeded the 24-hour average criteria level in 66 percent of both the upstream control samples and the samples taken downstream of the effluent pipe. The effluents from the disposal area caused elevations in the copper levels but, by 400 feet downstream of the effluent pipe, copper had returned to levels similar to upstream control levels. Cadmium concentrations exceeded the 24-hour average criteria in 17 percent of the control samples and 20 percent of the samples downstream of the effluent pipe.

Table 4. Applicable Water Quality Criteria and Standards for the Parameters Tested at the St. Paul Barge Terminal.

Parameter[1]	Proposed Update of Redbook Criteria[2]	Proposed MN WQ Standards[2] (June 1978)
Cadmium	1.2 / 18.2[3]	0.33
Chromium (Total)	-	50
Copper	4.3 / 36.2	5.8
Lead	95 / 687.5	80
Nickel	72 / 776	45
Ammonia Nitrogen	0.02 mg/l unionized	0.02 mg/l unionized
Zinc	65.7/336.3	42
Turbidity	-	25 NTU
Aldrin/Dieldrin	0.0019/1.2	0.003
Chlordane	0.024/0.36	0.03
DDT	0.00023/0.41	0.001
Endosulfan	0.042/0.49	0.05
Endrin	0.002/0.10	0.0025
Heptachlor	0.0015/0.45	0.008
PCB	0.0015/6.2	0.001
PCN	29 / 67	-
Toxaphene	0.007/0.47	5
Lindane	-	0.003
Mirex	-	0.001

[1]All values in ug/l unless otherwise indicated.

[2]A hardness of 190 was used in the calculation of criteria where applicable. This figure of 190 was derived from MPCA water quality monitoring station approximately 1 mile upstream of study area during the same time of year.

[3]Number to the left of slash is for 24-hour average criteria and number to the right is maximum permissible level at any one time.

Temperature and pH strongly influence the percentage of total ammonia nitrogen that is in the unionized form. Since temperature and pH were not measured in this study, it is difficult to compare the results of this study with the criteria of 0.02 ug/l unionized ammonia. However, given the range of pH and temperature normally found here at this time of year, it is possible that the elevated total ammonia nitrogen concentrations caused by the effluent from the confined on-land disposal area may have produced unionized ammonia nitrogen concentrations greater than the 0.02 ug/l water quality criteria. However, samples that may have had concentrations greater than 0.02 ug/l unionized ammonia were found only within 400 feet of the effluent pipe.

The Minnesota Pollution Control Agency's (MPCA) proposed water quality standards numerically are either slightly greater or less than the proposed Federal 24-hour average criteria. For the most part, the comparison to Federal 24-hour average criteria above holds true for a comparison of the results to the Minnesota proposed water quality standards, with the exception that the MPCA has developed standards for turbidity (25 NTU). All samples collected in the study, including pre-dredging and upstream control samples, exceeded the turbidity standard. However, the effluents from the disposal areas did cause further elevations in turbidity.

SUMMARY

Dredging to maintain the navigation channel at the St. Paul Barge Terminal dredge site, which is located in Pool 2 of the Upper Mississippi River, was accomplished with the 20-inch hydraulic dredge WILLIAM A. THOMPSON. Disposal of the dredged material occurred in a bermed on-land disposal area with a drop structure and culverts to allow for the return of effluent after a short retention time. Dredging was conducted at this site from 17 July 1979 to 6 August 1979. On 25 and 26 July 1979 this dredging and disposal operation was monitored for its effects on water quality.

The sediments from the St. Paul Barge Terminal dredge cut had from 2- to 6-percent fine materials (silts and clays). Settleability tests indicated that the bottom sediments had a high turbidity and suspended solids generation potential. Suspended solids showed a steep drop with time, but turbidity showed a gradual decrease with time. Bulk chemical analyses of sediments in 1978 (Anderson et al., 1979) from the St. Paul Barge Terminal historical dredge site indicated that the sediments ranged from moderately contaminated coarse material to heavily contaminated fine material compared with other areas on the Upper Mississippi River. The particle size data from this study suggest that the sediments dredged at the time the water quality monitoring was conducted fell between the two extremes in composition noted in the 1978 study. Therefore, the results of the water quality monitoring may not be totally representative of dredging either the coarser or finer materials present within the historical dredge site.

Large fluctuations in ambient water quality were observed in this study and are most likely attributable to seasonal fluctuations.

The water quality monitoring of the hydraulic dredging and disposal operation was done in two phases. The objective of phase I was to assess the general magnitude of changes in water quality (turbidity and suspended solids) within a 1-mile reach of the river downstream of the effluent pipe from the confined on-land disposal area.

a. Turbidity and suspended solids data correlated well ($r = 0.92$).

b. In phase I both turbidity and suspended solids showed significant increases (t-test) below the effluent pipe over upstream controls. Approximately a 12-percent increase in turbidity and suspended solids occurred below the effluent pipe in run 1.

c. The phase I data also showed that, within an hour after the effluent pipe stopped running, the effects on turbidity and suspended solids had disappeared.

d. The hydraulic cutterhead itself did not appear to cause any elevations in turbidity and suspended solids.

Phase II of this study assessed the trends in water quality with distance downstream of the effluent pipe. It also monitored selected chemical parameters, in addition to the indicator parameters of turbidity and suspended solids.

a. In phase II, biocides and PCB's were not detected in most of the water samples collected. However, PCB's were detected near the limits of sensitivity at 0.1 ug/l in one sample from the effluent pipe and 100 feet downstream of the effluent pipe. One effluent pipe sample also had detectable levels of dieldrin (0.01 ug/l).

b. Copper, lead, nickel, zinc, ammonia nitrogen, turbidity, and suspended solids concentrations were from two to six times higher in effluent pipe samples than in upstream control samples. Chromium showed less reaction, being only slightly elevated over upstream control values in the effluent from the confined on-land disposal area.

c. The chemical and physical parameters, except chromium, correlated well with each other.

d. Obvious trends with distance downstream of the effluent pipe were evidenced for the chemical and physical parameters. All the parameters showed relatively high concentrations within 200 feet of the effluent pipe. However, by 400 feet downstream of the effluent pipe, a rapid drop in concentrations had occurred. By 2,700 feet downstream of the effluent pipe, most of the parameters had returned to ambient levels, with some returning earlier than others. The data indicate that very rapid settling and dilution occurred near the disposal area and that the effect on water quality of the effluents from the disposal area was very localized.

None of the chemical parameters in any of the samples exceeded the proposed maximum permissible level at any one time (Federal Water Quality Criteria). However, where suffiecient sensitivity was achieved in the analyses for comparison with the criteria, PCB's, dieldrin, zinc, cadmium, and copper were the only parameters to exceed the levels for the proposed 24-hour average Federal Water Quality Criteria. It should be noted that since the monitoring did not occur over a 24-hour period, a 24-hour average concentration cannot be calculated, making this comparison somewhat tenuous.

a. PCB's, dieldrin, and zinc values exceeding the 24-hour average criteria were found only in samples from the effluent pipe and within 200 feet of the effluent pipe.

b. Copper and cadmium values exceeding tne 24-hour average criteria were found equally distributed among upstream control samples and those taken downstream of the effluent pipe. However, copper did show elevations below the effluent pipe, but by 400 feet downstream of the effluent pipe, copper had returned to ambient levels.

CONCLUSIONS

On 25 and 26 July 1979, a 20-inch hydraulic dredging operation and subsequent disposal into a confined on-land disposal site with an effluent return were monitored. The study area was located in Pool 2 of the Upper Mississippi River.

In this study, the 20-inch hydraulic cutterhead had no observable impacts on water quality. Impacts on water quality mainly resulted from the effluent from the confined on-land disposal area.

Turbidity and suspended solids showed a significant increase below the effluent pipe from the confined on-land disposal area. Approximately a 12-percent increase in both turbidity and suspended solids levels was observed. However, turbidity and suspended solids and selected chemical parameters had dropped to near-ambient levels by 400 feet downstream of the effluent pipe and were at ambient levels 2,700 feet downstream, with some parameters returning to ambient levels sooner. In addition, within 1 hour after the effluent pipe had stopped running, the water quality effects had disappeared.

Most of the chemical parameters showed a good correlation with turbidity and suspended solids. This supports the recommendations made by others (GREAT I WQWG, 1978) that turbidity and suspended solids may be useful indicators of water quality impacts.

In the proposed update of the Redbook, the Environmental Protection Agency has developed sets of two numerical criteria for each of the parameters on the toxic substance list. These two criteria are a maximum permissible level at any one time and a 24-hour average level. None of the chemical parameters in any of the water samples, including those taken directly from the effluent pipe, had values exceeding the proposed Federal Water Quality Criteria for the maximum permissible levels at any one time. Monitoring on a 24-hour basis so that a 24-hour average level could be established was not done in this study. It is therefore difficult to compare the results of this study with the proposed 24-hour average Federal Water Quality Criteria. However, to indicate a potential concern and because the proposed Minnesota Pollution Control Agency water quality standards are similar to the 24-hour average criteria, a comparison of the results of this study with the 24-hour criteria was made. This comparison indicated that polychlorinated biphenyls, dieldrin, zinc, cadmium, and copper were the only parameters which had levels in some of the water samples exceeding the 24-hour average criteria. For PCB's, dieldrin, and zinc, values exceeding the 24-hour average criteria were found only in water samples from the effluent pipe and within 200 feet of the effluent pipe. Copper and cadmium values exceeding the 24-hour average criteria occurred in both upstream control samples and downstream effluent pipe samples. However, the diposal operation did elevate copper concentrations compared to upstream controls, within 400 feet of the effluent pipe.

In summary, it would appear that the hydraulic dredge had very little impact on water quality. However, the effluents from the disposal area did cause degradation of water quality. The degradation of water quality appeared to be short-term (within an hour) and localized (within a mile). Past sediment data (Anderson et al., 1979) and subsequent monitoring of effluents for the entire dredging operation (see page 70) indicate that the results of this study may not have been indicative of water quality effects resulting during the entire dredging operation. This makes it difficult to make overall conclusions regarding the effects of dredging and disposal on water quality at the St. Paul Barge Terminal.

TEEPEOTA POINT (RIVER MILE 757.5) MONITORING OF WATER QUALITY CHANGES RESULTING FROM HYDRAULIC DREDGING AND EFFLUENT FROM CONFINED ON-LAND DISPOSAL

OBJECTIVE

The objective of the study was to determine the areal extent and magnitude of turbidity and suspended solids changes resulting from a WILLIAM A. THOMPSON hydraulic dredging operation and the effluent from confined on-land disposal of the dredged material. In addition, a limited sampling was done to assess the magnitude of impacts of dredging and disposal operations on the concentrations of selected metals, ammonia nitrogen, pH, temperature, and dissolved oxygen. Also, in situ bioassays were run to assess the acute toxicity of effluents from the confined on-land disposal area.

METHODS

DESCRIPTION OF SAMPLING SITE

Teepeota Point dredge cut is located at approximately Cairo mile 757.5 on the Mississippi River, approximately 2 miles downstream from the city of Wabasha, Minnesota. Based on historical records of maintenance, the dredge site at Teepeota Point has a dredging frequency of 65 percent, requiring maintenance approximately two out of every three years. The average annual volume is fourth highest of dredge sites in the St. Paul District. Historically, the volume removed at this site per dredging event averages 60,000 cubic yards.

The 1979 dredging activity at this site invloved the placement of approximately 74,700 cubic yards of material into a confined on-land disposal site on the left descending bank in Wisconsin, near Cairo mile 757.5. Dredging was accomplished with the WILLIAM A. THOMPSON, a 20-inch hydraulic dredge. The confined on-land disposal area consisted of a bermed area to confine the dredged material and a culvert to allow for the return of effluent. Maintenance dredging was initiated on 16 August 1979 and completed on 25 August 1979.

EXPERIMENTAL DESIGN

Sediment - Prior to dredging operations, three sediment samples were collected with a Ponar bottom sampler from the area to be dredged (refer to Figure 4). Particle size and settleability analyses were conducted on all sediment samples.

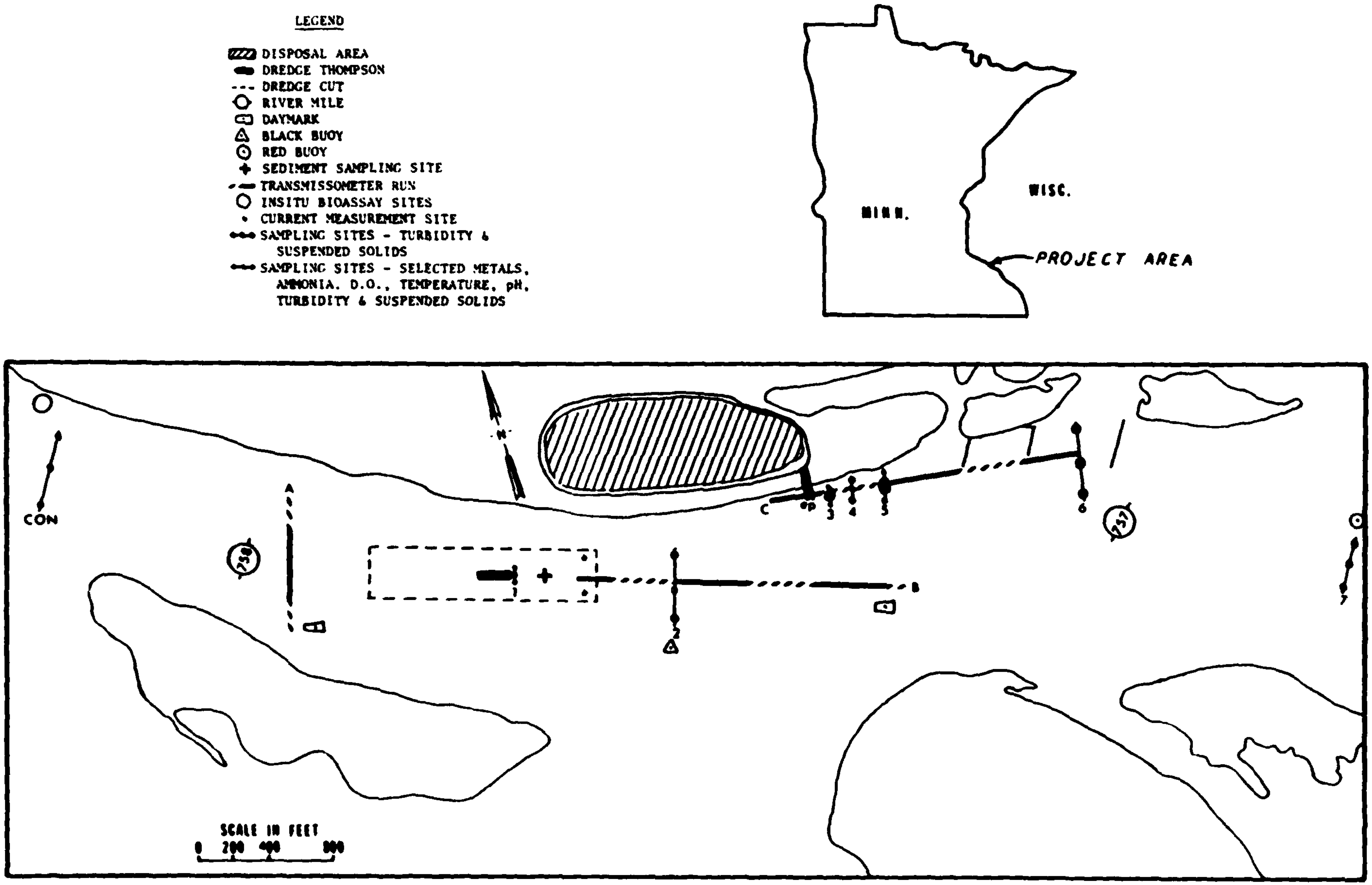


Figure 4. Teeneota Dredge Site on the Upper Mississippi River: Sampling Site Locations.

Water - Discrete water samples were taken during dredging on 22 August 1979 with the use of Van Dohrn water samplers. Sampling sites were located on transects 2800 feet upstream of the dredging operation; 50 and 1000 feet downstream of the dredging operation; and 100, 200, 400, 1600, and 3200 feet downstream of the effluent return from the confined on-land disposal area (Figure 4). Each transect had three sampling sites designated east, middle and west. At each site, a water sample was collected 3 feet from the bottom. Two discrete water samples were also collected directly from the effluent generated from the confined on-land disposal area.

After one sample was collected at each of the above sites, the entire sampling design was repeated again. All of the water samples collected were analyzed for turbidity and suspended solids. Fourteen of the water samples from the first run (refer to Figure 4) were analyzed for selected metals, ammonia nitrogen, pH, temperature, dissolved oxygen, turbidity, and suspended solids. Prior to the water sampling, current velocity was measured with a mechanical current meter. Measurements were taken 1 foot from surface and bottom and at middepth at three sites (refer to Figure 4).

In addition to discrete water samples, a recording in situ transmissometer (Hydro Products Model 912) was used to measure the effects of the dredging and disposal operation on light transmission. The transmissometer was towed through the water along three transects at depths of 8 feet for transects 1 and 2 and 4 feet for transect 3 (refer to Figure 4). Transect 1 was a cross-section of the river upstream of the dredging and disposal operation. Transect 2 was a transect parallel to the current direction, downstream of the dredging operation. Transect 3 was a transect parallel to the current, downstream and upstream of the discharge point from the confined on-land disposal area.

In situ bioassays - In situ acute toxicity exposures to the effluent from the confined on-land disposal area were run on fathead minnows (*Pimephales* spp.). The test cages for the fathead minnows consisted of 12" by 12" cylindrical baskets made from 1/8-inch mesh galvanized steel hardware cloth. On 20 August 1979, approximately 200 fathead minnows were purchased from a local bait shop and equally divided amongst three test cages (approximately 70 in each). The test cages were then suspended at middepth in the water column, at a site located above the dredging operation to acclimate the minnows to background conditions on the Upper Mississippi River for 24 hours prior to the exposures. After the 24-hour acclimation period was over on 21 August 1979, any dead minnows and some of the live minnows were removed from the three test cages, so that exactly 50 minnows were left in each of the three test cages. One test cage was then positioned at each of three stations on the Upper Mississippi (refer to Figure 4). One station was located upstream of the dredging and disposal operation and served as a control. The remaining two stations were located 100 and 400 feet downstream of the effluent pipe from the confined on-land disposal area. It should be noted that a visible plume existed near the disposal area and that the test cages were positioned so that they were in the plume from the disposal area. The cages were then checked daily, noting mortality and removing expired minnows. The exposures were stopped at the end of three days on 24 August 1979 because the dredging project was terminated.

ANALYTICAL METHODS

Samples were chilled after collection and shipped as soon as possible for laboratory analysis. Particle size analysis of sediment samples was accomplished by use of standard mesh screens and hydrometer for finer particles. Settleability tests were conducted according to the methods described by Anderson et al., 1979. Particle size and settleability tests were conducted by Missouri River Division Laboratory, Omaha, Nebraska.

Analyses of water samples for metals, ammonia nitrogen, turbidity, and suspended solids were conducted by the U.S. Geological Survey Laboratory in Atlanta, Georgia, according to methods described by Skougstad et al., 1979, and Goerlitz and Brown, 1972.

Dissolved oxygen and temperature were field tested by St. Paul District Corps personnel with a YSI dissolved oxygen instrument (Model 57); pH was also tested in the field using a Bekhman pH meter (Model 123300).

RESULTS

FIELD CONDITIONS

Weather conditions on 22 August 1979 were not adverse, with air temperatures averaging 70° F. During the sampling, no observable interference, such as barge traffic, occurred. Current was relatively swift on 22 August, with a mean velocity, 1 foot from the surface, of 2.6 feet/second and a mean velocity, 1 foot from the bottom, of 1.8 feet/second in the main channel. Current velocities along the main channel border near the disposal area were lower, with a mean velocity of 1.2 feet/second.

SEDIMENT

Particle Size. Sediment samples collected from the area to be dredged on the day of sampling were coarse (Appendix Table A1). Silts and clays contributed to only 1 to 2 percent of the total particle size distribution. The bottom sediments consisted mainly of medium-to coarse-sized sand particles. The particle size data from this study correspond closely to sediment surveys done at the site in 1978, and are typical of many of the historical dredge sites within this reach of the Mississippi River (Anderson et al., 1979).

Settleability. Settleability tests conducted on two sediment samples from the dredge indicated that the dredged sediments had a relatively low turbidity and suspended solids generation potential (Appendix Tables A2 and A3). Turbidity and suspended solids initial mean values were 51.3 NTU and 500 mg/l, respectively. Within 2 hours of settling, turbidity and suspended solids mean values were 17 NTU and 105 mg/l, indicating rapid settling of the dredged sediment.

Bulk Chemical Constituents. Although bulk chemical analyses were not conducted in 1979, the Teepeota dredge site was monitored in 1978 (Anderson et al., 1979). The 1978 results showed no biocide or PCB contamination of the sediments, and metals and nutrients were found only at low levels.

IN SITU BIOASSAYS

The in situ bioassays were unsuccessful. Mortality of the fathead minnows occurred within all of the cages (Appendix Table A8). However, mortality was considerably greater in the upstream control cages than in the cages located downstream of the disposal area. The observed mortality was probably attributable to the sensitivity of the fatheads to current. The cages below the disposal area became covered with detritus, which may have served as a refuge from the current for the fathead minnows. The fact that this detritus covering did not take place in the controls probably accounts for the greater mortality noted in the control cages. In general, it would appear that the lethal effects of the high current obscured any toxic effects of the effluent from the confined on-land disposal area. Better results might have been achieved with the use of another fish species that normally resides in a high current area, such as channel catfish (Ictalurus punctatus), the use of deflector shields on the upstream ends of the cages to create a sanctuary from the current for the test organisms, and the use of less abrasive material for construction of the cages.

TRANSMISSIBILITY

A recording transmissometer was towed along three transects (see Figure 4) to assess the effects on light transmission caused by the dredging and disposal operation. On Transect 1, a cross-section of the river upstream of the dredging and disposal operation, percent transmission varied from 46 to 50 percent (Figure 5). Less light transmission was found along the main channel border, with the highest transmission occurring in the main channel.

Transect 2 was located downstream of the hydraulic dredge and parallel to the current. Percent transmission varied by only 1 percent, indicating that the hydraulic dredging had little or no effect on the transmissibility of the water.

Transect 3 was located up and downsteam of the effluent pipe from the confined on-land disposal area. Upstream of the effluent pipe, percent transmission was approximately 50 percent (see Figure 6). Within 200 feet downstream of the effluent pipe, percent transmission varied from 34 to 43 percent, indicating a substantial drop in transmission. By 800 feet downstream of the effluent pipe, percent transmission had returned to upstream values. However, at 1,000 feet downstream of the effluent pipe, transmission dropped again. Approximately 1,000 feet downstream of the effluent pipe there was a wing dam and subsequent shallower water. It would appear that the drop in transmission 1,000 feet downstream of the effluent pipe was due to an increase in turbulence and mixing of the water column caused by the wing dam and shallow water. Approximately 1,400 feet downstream of the effluent pipe, percent transmission was again approaching upstream values.

Immediately downstream of the effluent pipe, drastic fluctuation occurred in percent transmission, indicating that the plume was sporadic rather than uniform.

WATER QUALITY

Physical Parameters. At every site, water samples were collected in two runs and analyzed for turbidity, suspended solids, specific conductance and pH (Appendix Table A9). In the statistical analysis of this data, no differences were found between the two runs; therefore, the data from the two runs were pooled. Analysis of variance was conducted on the turbidity, suspended solids, specific conductance data to assess the significant differences between the control, 50 feet downstream of the hydraulic dredge and 1,000 feet downstream of the hyrdaulic dredge samples. No changes in pH were observed; therefore, pH was not statistically analyzed. Of the three parameters tested (turbidity, suspended solids, and specific conductance), only suspended solids showed a significant (α =.05) difference among the three sampling locations (Table 5). Suspended solids concentrations were highest in the control samples, with a mean concentration of 21.3 mg/l, compared with a mean concentration of 11.83 mg/l, 50 feet downstream of the hydraulic cutterhead.

Figure 5. Transmissibility of River Water Along a Cross Section of the Mississippi River Upstream of the Dredging Operation at the Teepeota Dredge Site (Cross Section goes from the Left Descending Bank to the Right Descending Bank) (Transect 1, Figure 4).

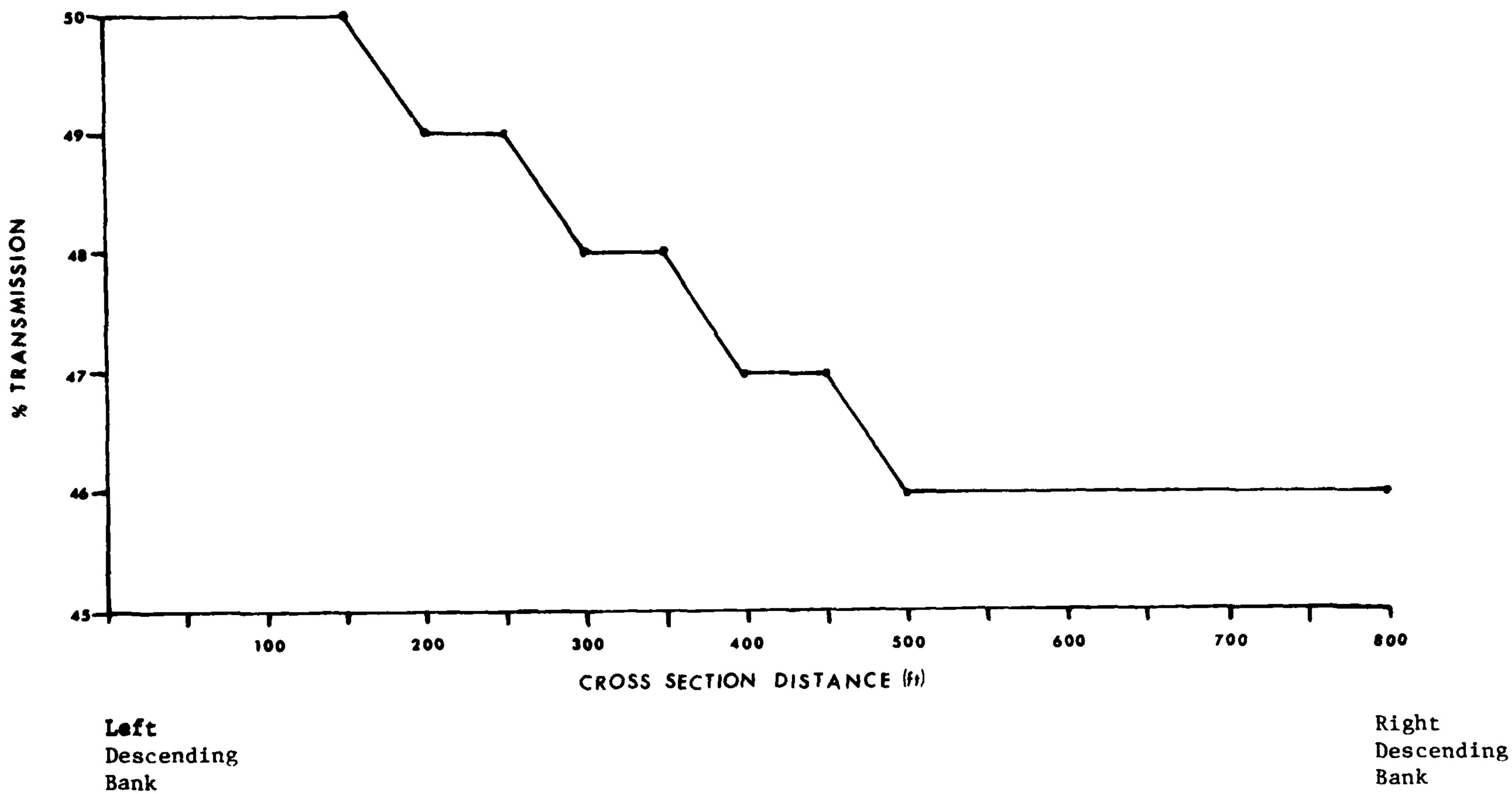


Figure 6. Transmissibility of River Water Upstream and Downstream of the Effluent Pipe at the Teepeota Dredge Site on the Upper Mississippi River (Transect 3, Figure 4).

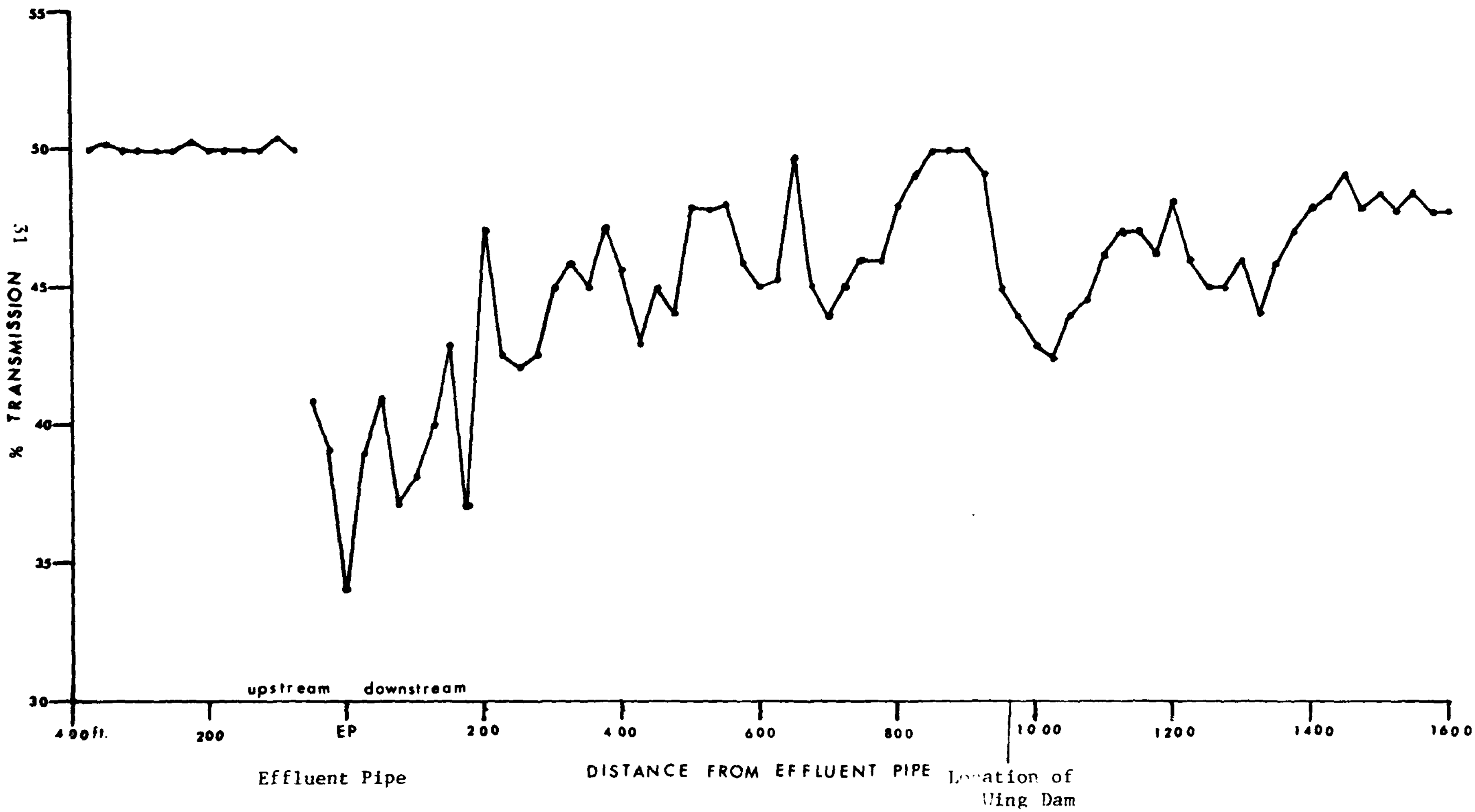


Table 5. Mean Values of Turbidity, Suspended Solids, and Specific Conductance of Locations Up and Downstream of the Hydraulic Cutterhead at the Teepeota Point Dredge Site.

Location	Turbidity (NTU)	Suspended Solids* (mg/l)	Specific Conductance
Control	4.0	21.33	481.5
50 feet downstream of hydraulic cutterhead	4.17	11.83	483.5
1,000 feet downstream of hydraulic cutterhead	4.33	13.83	462.3

*Significant differences in the analysis of variance (α=.05)

The hydraulic cutterhead apparently had little effect on water quality as measured by pH, specific conductance, turbidity, and suspended solids. Turbidity, suspended solids, and conductance data (Appendix Table A9) from sample locations 3, 4, 5, 6, and 7 which were located 100, 200, 400, 1,600 and 3,200 feet downstream of the effluent pipe (Figure 4) were statistically analyzed by regression analysis. Samples from 5E, run 1 and 6E, run 2 were omitted from the statistical analysis because they were considered outlier values. These samples were taken in shallow water near the disposal island and may have been contaminated with bottom material. No significant regression of turbidity values with distance was found. Plotting turbidity values versus distance below the effluent pipe indicates that out of 12 available points (Figure 7), only three high readings occurred at 100- and 200-foot transect overall (no elevations in turbidity occurred downstream of the effluent pipe over the values from above the effluent pipe).

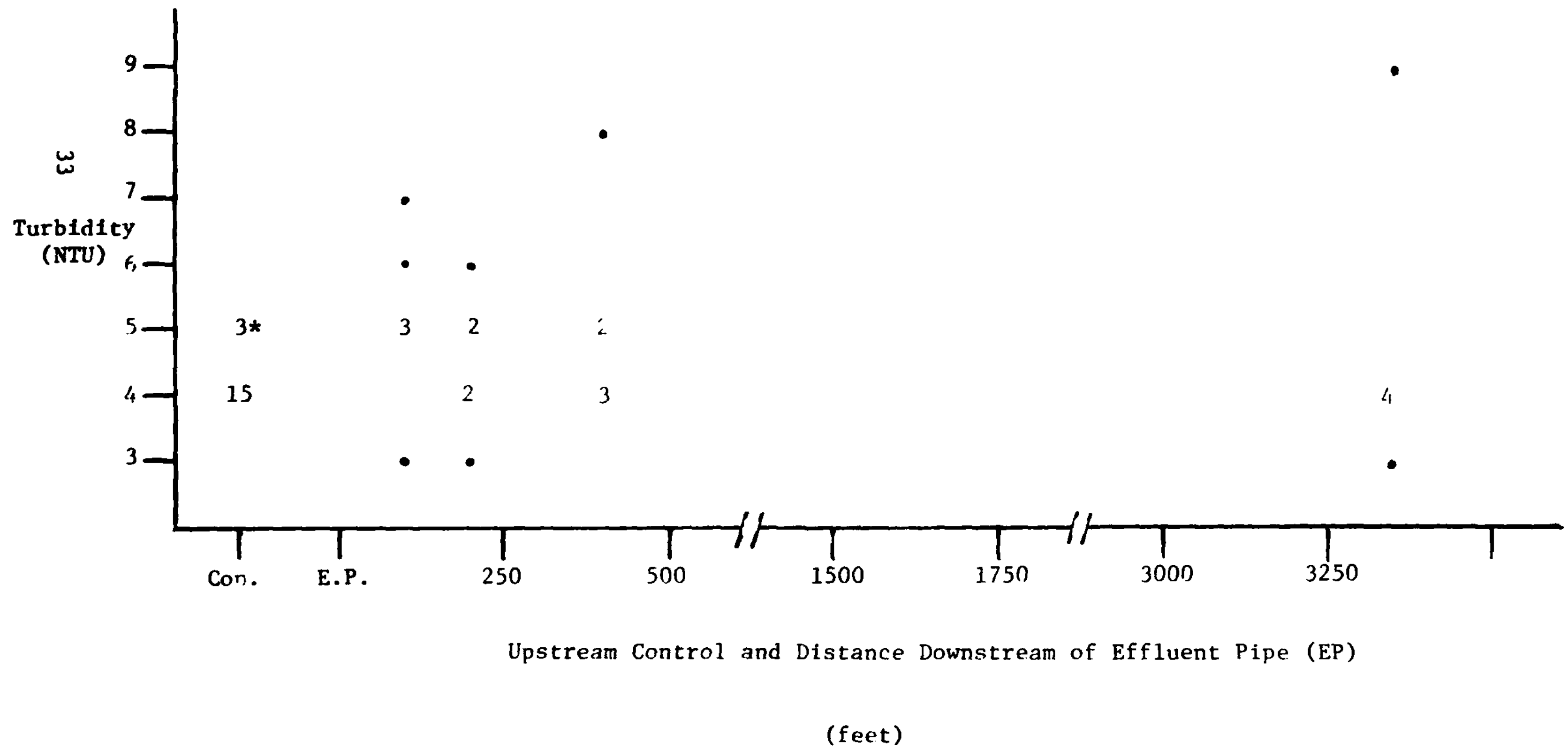
Regression of suspended solids with distance below the effluent pipe was also not significant. However, there was a slight elevation over upstream values in suspended solids within 1,600 feet of the pipe (Figure 8).

Regression of specific conductance with distance downstream of the effluent pipe was significant and had a positive slope. A highly significant decrease in values occurred below the effluent pipe and was sustained out to 1,600 feet (Figure 9).

Very poor correlations were found among specific conductance, turbidity, and suspended solids values in the samples downstream of the effluent pipe.

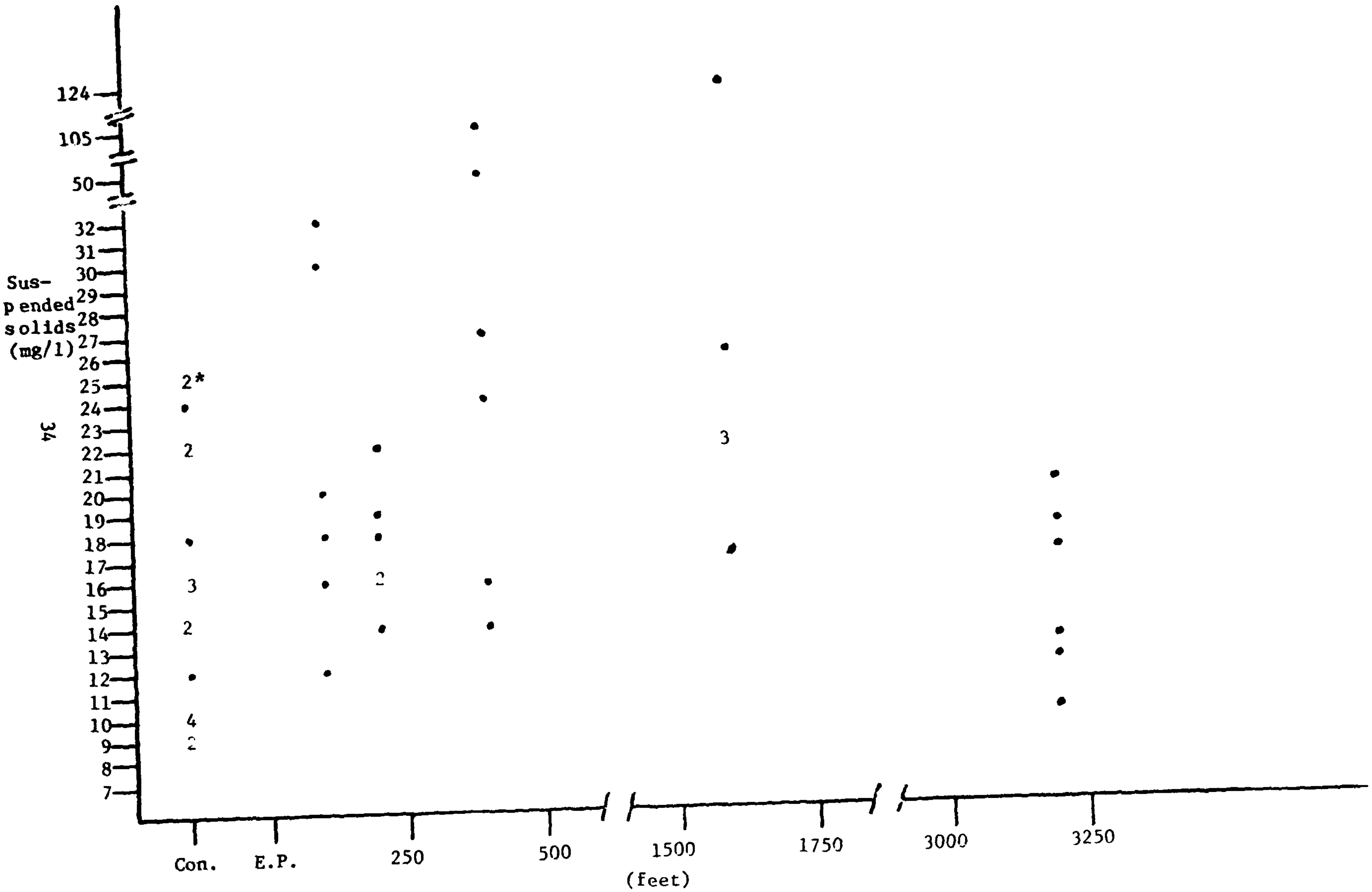
Selected Chemical Parameters. At selected sampling locations (upstream controls; 50 feet downstream of the hydraulic cutterhead; the effluent pipe; and 100 and 400 feet downstream of the effluent pipe (Figure 4), samples were collected in run 1 for analysis of selected chemical parameters (Appendix Table A10). The mean concentrations of each of the chemical parameters for these selected sampling site locations are summarized in Table 6. For all the parameters except dissolved oxygen, the mean concentrations of samples collected from the effluent pipe were slightly greater than the mean concentrations of the upstream control samples. However, the only parameters that appeared to show any elevations in concentrations immediately downstream of the dredge and/or effluent pipe were copper, lead, NH_3 & NH_4, and temperature. These elevations were rather small and were not statistically significant in one-way analysis of variance tests. Of the other parameters tested, nickel was the

Figure 7. Comparison of Turbidity Values Up- and Downstream of the Effluent Pipe at the Teepeota Dredge Site.



* Number of samples with the same turbidity value at a given location.

Figure 8. Comparison of Suspended Solids Concentrations Up-and Downstream of the Effluent Pipe at the Teepeota Dredge Site.



Upstream Control and Distance Downstream of Effluent Pipe (EP)
*Number of samples with the same suspened solids value at a given location.

Figure 9. Comparison of Specific Conductance Data Up-and Downstream of the Effluent Pipe at the Teepeota Dredge Site.

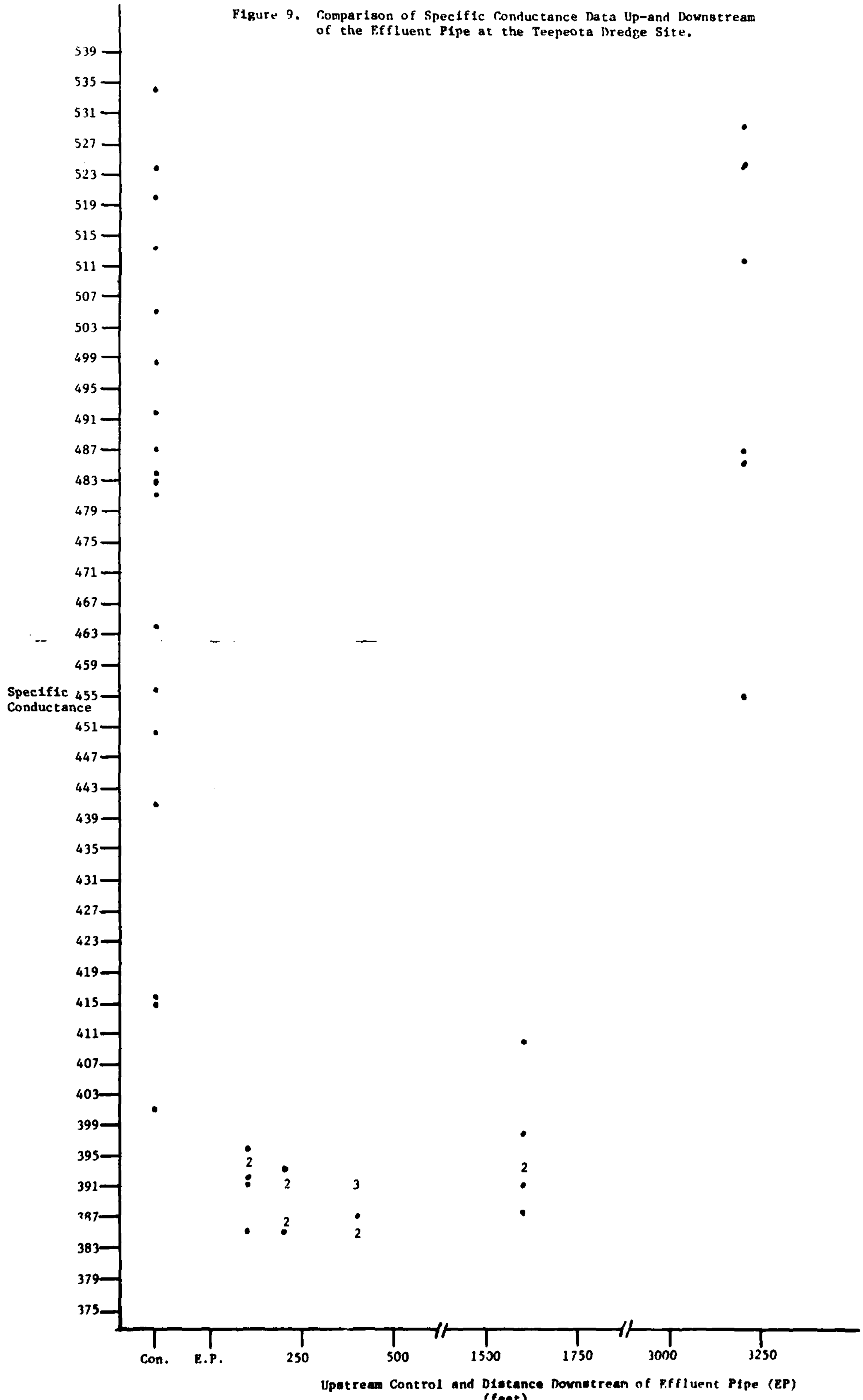


Table 6. Comparison of Mean Concentrations of Selected Chemical Parameters From Five Sampling Locations at the Teepeota Point Dredge Site

SAMPLE SITE LOCATION	PARAMETER								
	Cadmium ug/1	Chromium ug/1	Copper ug/1	Lead ug/1	Nickel ug/1*	Zinc ug/1	(NH_3 & NH_4) mg/1	Dissolved Oxygen mg/1	Temperature OC
Upstream Controls	1	8	3.3	23	6.7	10	.03	7.8	22.0
50' Downstream(Dredge)	0.7	8.7	4.3	4.0	4.0	10	-	7.1	22.5
Effluent Pipe(EP)	1.5	9.5	6	6.0	12.5	30	.15	7.7	24.0
100' Downstream (EP)	1.3	8.3	4.3	4.3	4.3	10	.10	7.7	22.3
400' Downstream (EP)	1	8.0	4.7	4.7	5.7	13	.10	7.7	22.2

*Statistically significant in analysis of variance (α =.05).

only parameter that showed a statistically significant difference in one-way analysis of variance tests among the five sampling locations. This significant difference is attributable to the high values observed in the effluent pipe—almost twice the ambient levels. There were no differences in nickel concentrations between upstream control samples, downstream of the dredge samples, and downstream of the effluent pipe samples.

Correlation analyses were run on the chemical and appropriate physical data. Turbidity and suspended solids correlated well with each other (0.93). Correlation analyses of the chemical parameters with suspended solids and turbidity showed that a good relationship existed between nickel and the physical parameters, turbidity and suspended solids (Table 7). A much looser relationship existed between the other chemical parameters and the physical parameters. It should be noted that the correlations in Table 7 were calculated using the data from the effluent pipe as well as the river water samples. The same calculations, using only the river water samples, would show practically no correlation, due to the relatively narrow range of values and the relative lack of effects on the water quality of the river of the dredging and disposal operations.

Table 7. Correlations of the Chemical Parameters with suspended Solids and Turbidity

	Chromium	Copper	Lead	Nickel	Dissolved Oxygen	Specific Conductance
Suspended solids	.46	.55	.45	.83	.31	.00
Turbidity	.52	.65	.50	.87	.06	.26

Comparison with Water Quality Criteria and Standards. The proposed Federal water quality criteria for the maximum permissible level at any one time and the 24-hour average level (for each of the parameters) are listed in Table 4. None of the parameters investigated in this study exceeded their respective maximum permissible levels. Cadmium and copper exceeded the 24-hour average level in some of the discrete samples collected. It should be noted that since the monitoring did not occur over a 24-hour period, a 24-hour average concentration cannot be calculated, making the comparison somewhat tenuous. Copper values in discrete water samples exceeding the 24-hour average level were found immediately downstream of the hydraulic dredge, in the effluent, and immediately downstream of the disposal area.

The Minnesota Pollution Control Agency's (MPCA) proposed water quality standards numerically are either slightly greater or less than the proposed Federal 24-hour average criteria. For the most part, the comparison between Federal 24-hour average criteria and the Minnesota proposed water quality standards holds true, with the exception that the MPCA has developed standards for turbidity (25 NTU). The only samples that exceeded this standard were those collected from the effluent pipe.

SUMMARY

From 16 August 1979 to 25 August 1979, Teepeota Point dredge cut (Cairo mile 757.5) was hydraulically dredged to maintain the 9-foot navigation channel on the Upper Mississippi River. Disposal of the dredged material occurred in a confined on-land disposal site with a drop structure and culverts to allow for a return of effluent.

The dredged sediments mainly consisted of sand-sized particles with only traces of silts and clays. Settleability tests indicated the dredged material had a low turbidity and suspended solids generation potential when resuspended and had a short settling time.

In situ acute toxicity exposures to the effluent from the confined on-land disposal areas were run on fathead minnows (Pimephales spp.); these exposures, however, were unsuccessful. Mortality of fathead minnows occurred in all test cages, with the greatest mortality occurring in upstream control cages. The observed mortalities probably resulted from stress due to the exposure of the fatheads to relatively high current rather than from factors associated with the dredging operation.

Results from an in situ recording transmissometer indicated the hydraulic cutterhead had very little effect on the river water's ability to transmit light. However, the effluent from the disposal area decreased the river water's ability to transmit light within 800 feet downstream of the effluent pipe. It also indicated that hydraulic features near the disposal areas may greatly influence the return to background levels.

Turbidity, suspended solids, specific conductance, and pH did not show any statistical (analysis of variance) elevations downstream of the hydraulic dredge. Effluents from the disposal area had turbidity and suspended solid values exceeding upstream control values. In addition, there appeared to be a slight elevation in turbidity and suspended solids within 1,600 feet downstream of the disposal area. However, regressions of turbidity and suspended solids with distance downstream of the disposal area were not significant. A significant positive regression of specific conductance with distance downstream was observed, indicating that the effluents from the disposal area caused a decrease in specific conductance with a gradual return to ambient levels within 3,200 feet. The effluents from the disposal area appeared to have no effects on pH.

In addition to a detailed monitoring of turbidity, suspended solids, pH, and specific conductance, selected chemical parameters were monitored at several sample locations. Cadmium, chromium, copper, lead, nickel, zinc, total ammonia (NH_3 & NH_4), and temperature values in the effluent from the disposal area were greater than upstream control levels. However, none of the parameters showed statistically significant elevations downstream of the disposal area over upstream control levels, indicating that rapid mixing and dilution occurred near the disposal area.

None of the parameters in any of the samples collected exceeded the applicable proposed Federal water quality criteria for the maximum permissible level at any one time. In some samples, cadmium and copper values exceeded the levels of the applicable proposed Federal water quality criteria for 24-hour average levels, and applicable proposed Minnesota State water quality standards. In addition, turbidity exceeded the Minnesota water quality standard of 25 NTU, but only in the effluent from the disposal area.

CONCLUSIONS

On 22 August 1979, a 20-inch hydraulic dredging operation and subsequent disposal into a confined on-land disposal site with an effluent return were monitored. The study area was located in Pool 5 of the Upper Mississippi River in an area of granular bottom material.

In this study, the 20-inch hydraulic cutterhead had no observable effects on the selected physical and chemical parameters investigated. The effluents from the disposal area contained concentrations, for most of the parameters investigated, greater than upstream control levels. However, no statistically significant increases downstream of the disposal area were observed for any of the parameters investigated, although there did appear to be slight elevations of turbidity, suspended solids, copper, lead, total ammonia, and temperature immediately downstream of the disposal areas. Specific conductance showed a significant positive regression with distance downstream of the effluent pipe, indicating that the effluent from the disposal area decreased specific conductance with a gradual return to ambient levels at 3,200 feet.

The results of an in situ recording transmissometer indicated that the hydraulic dredge had no effects on the river water's ability to transmit light, but that the effluents from the disposal area caused a localized (within 1,000 feet) decrease in the transmissibility of river water.

In summary, it would appear that the hydraulic dredge did not cause any appreciable changes in water quality, but that the effluents from the disposal area caused some minor and localized changes in water quality.

BELOW WEST NEWTON DREDGE CUT (CAIRO MILE 746.6)
MONITORING OF TURBIDITY AND SUSPENDED SOLIDS
CHANGES RESULTING FROM HYDRAULIC DREDGING
AND EFFLUENT FROM CONFINED ON-LAND DISPOSAL

OBJECTIVE

The objective of the study was to determine the areal extent and magnitude of turbidity and suspended solids changes resulting from a WILLIAM A. THOMPSON hydraulic dredging operation and the effluent from confined on-land disposal of the dredged material.

METHODS

DESCRIPTION OF SAMPLING SITE

The Below West Newton dredge cut area is located approximately 6 miles downstream of Alma, Wisconsin, at Cairo mile 746.5 on the Upper Mississippi River. The area is located along a bend in the main navigational channel and, because of this bend, shoaling occurs quite frequently in this area, requiring maintenance dredging approximately every other year. From 1956 to 1978, the volume of material dredged per job has ranged from 8,000 to 135,000 cubic yards, with an average per job of 73,400 cubic yards.

During the 1979 dredging season, one cut was dredged to a depth of 13 feet, with the WILLIAM A. THOMPSON removing 32,800 cubic yards of accumulated sediments. Work began on 27 August 1979 and was completed on 30 August 1979. Placement of the dredged material was on an island at Cairo mile 746.7, on the right descending bank in Minnesota. The disposal site was located approximately 3,000 feet downstream of the dredge cut (see Figure 10). The disposal area consisted of a bermed containment area that covered approximately 6 acres and had an inside capacity for 65,000 cubic yards of dredged material.

EXPERIMENTAL DESIGN

Sediment. Prior to dredging operations, three sediment samples were collected with a 9-inch Ponar bottom sampler from the area to be dredged (see Figure 10). Particle size analysis and settleability tests were conducted on all sediment samples.

Areal Extent. Discrete water samples were collected during dredging operations on 30 August 1979 for analysis of turbidity and total suspended solids. Sample sites were located on transects 1,500 feet upstream of the dredge; 300 and 1,000 feet downstream of the hydraulic cutterhead; 200 feet upstream of the disposal pipe from the confined on-land area; and 0, 100, 200, 400, 800, 1,600, and 3,400 feet downstream of the disposal pipe from the confined on-land disposal area (see Figure 10).

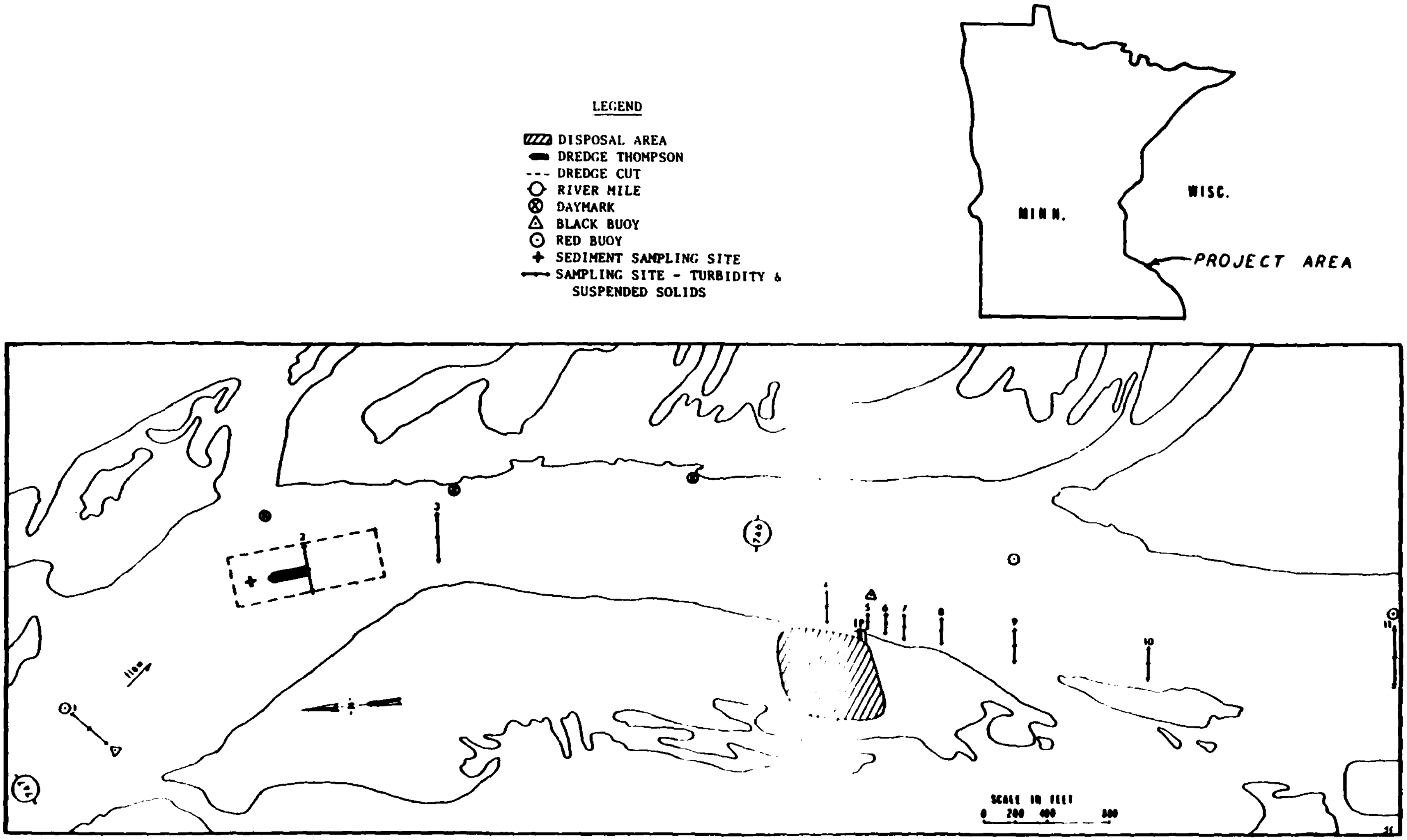


Figure 10. Below West Newton Dredge Site on the Upper Mississippi River: Sampling Site Locations.

Each transect had three sampling sites designated east, middle, and west. Samples were collected simultaneously at mid-depth from each of the sites on a given transect. Two discrete water samples were also collected directly from the effluent pipe. After one water sample had been collected from each of the sites described above, the entire sampling design was repeated.

ANALYTICAL METHODS

Samples were chilled after collection and shipped as soon as possible for laboratory analysis. Collection and analysis of turbidity and suspended solids samples followed guidelines set forth in the U.S. Environmental Protection Agency's "Methods for Chemical Analysis of Water and Wastes," July 1974. Particle size analysis of sediment samples was accomplished by use of standard mesh screens and hydrometer for finer particles. Settleability tests were run according to methods described by Anderson et al., 1979. All analyses were conducted by Environmental Protection Laboratory, St. Cloud, Minnesota.

RESULTS

FIELD CONDITIONS

Weather conditions on the day of sampling were sunny and calm with air temperatures around 36°F. Current measurements were not taken at this site; however, the river appeared to be slightly elevated on the day of sampling due to the heavy rains occurring within the week prior to sampling, and the current appeared to be very swift.

Sampling was delayed at various points due to barge traffic and one operational shutdown. Sampling on Run 1 was initially delayed 10 minutes because of a passing barge. An operational shutdown of the dredge between samples 4 and 5 of run 1 caused an additional 15-minute delay. Between runs 1 and 2, barge traffic caused a delay of one-half hour. Run 2 was completed without further disturbance.

SEDIMENT

Particle Size. Analysis of the sediments collected from the dredge cut area indicated that the sediments were extremely coarse (Appendix Table A1). Silts and clays made up less than 1 percent of the total particle size distribution. The sediments consisted of predominantly medium-grained sands, with a trace of gravel.

Settleability. In the three samples tested, initial mean values for turbidity and suspended solids were 132 NTU and 469 mg/l, respectively (Appendix Table A2 and A3). At the end of 1 hour of settling, turbidity had a mean value of 23 NTU and suspended solids a mean value of 33.7 mg/l. This would indicate that the sediments from the Below West Newton dredge site had a low-to-moderate turbidity and suspended solids generation potential and a fairly rapid settling over time.

WATER

General. Turbidity ranged from 43 to 58 NTU in all river samples, except one which had a value of 73 NTU which was deemed an outlier and not included in further analysis of the data (Appendix Table A11). Suspended solids ranged from 122 to 232 mg/l in all river samples.

Ambient levels were approximately ten times those recorded for the study conducted at Teepeota Point dredge cut only eight days prior to this study and located within ten miles of the Below West Newton dredge cut. This dramatic change in ambient levels was probably due to the heavy rainfall occurring prior to sampling at the Below West Newton dredge cut and the associated increased discharge of the river. In addition, the Below West Newton dredge cut is located only 3 miles downstream of the mouth of a large tributary, the Zumbro River. During high discharge times the Zumbro River carries large amounts of suspended and bed-load material into the Mississippi River.

The samples collected from the effluent pipe indicate that the disposal operation was a point source of suspended material (Appendix Table A-11). Turbidity values from the effluent pipe were more than 10 times greater than ambient river water and had a mean value of 633 NTU. Suspended solids values were 5-10 times greater in the effluent pipe than in ambient river water. The effluent had a mean concentration of 1,275 mg/l suspended solids. With the exception of the monitoring of the dredging operation at the St. Paul Barge Terminal, located in Pool 2, the turbidity and suspended solids values from the effluent pipe were the highest recorded in the 1979 monitoring study.

Statistical Evaluation. The turbidity and suspended solids data were statistically analyzed by a three-way analysis of variance. The three factors considered were the distances up- and downstream of the dredge and effluent pipe, sampling site location on a transect, and sampling runs. The analysis of variance indicated that there were significant (α=.05) differences in values with distance up- and downstream of the dredge and the effluent pipe (Table 8). There were approximately 6 percent increases in turbidity and suspended solids 300 feet downstream of the hydraulic cutterhead. However, 1,000 feet downstream of the dredge, no substantial differences from control values were evidenced for either turbidity or suspended solids. Within 400 feet of the effluent pipe, an elevation in turbidity over upstream of the dredge and effluent pipe samples occurred. Further downstream, no substantial differences from upstream control values were found. Suspended solids did not show the same pattern as turbidity below the effluent pipe. The only differences from the suspended solids control values occurred at two distances from the effluent pipe; a decrease at 1,600 feet and an increase at 3,400 feet. This is unexpected and probably is unrelated to the disposal and dredging operation.

Table 8. Mean Turbidity and Suspended Solids Values for Various Distances Up- and Downstream of the Hydraulic Cutterhead or the Effluent Pipe from the Confined On-Land Disposal Area.

General Sampling Area	Distance From Dredge or Effluent Pipe(Feet)	Turbidity (NTU)*	Suspended Solids (mg/1)*
Upstream of Dredge and Effluent Pipe	---	49	155
Downstream of Dredge	300	52	163
	1,000	51	150
Near and Downstream of The Effluent Pipe	-200	53	159
	0	53	154
	100	53	155
	200	51	158
	400	52	149
	800	51	157
	1,600	50	143
	3,200	51	166

* Significant differences (α=.05) in the analysis of variance with distance up- and downstream of the dredge and disposal area.

In the analysis of variance, no significant differences were found for turbidity with location on a transect (Table 9). However, there were significant differences in suspended solids concentrations with location on the transect. The east position, which was located closest to the main channel and farthest from the disposal area, had the highest value. This is contrary to what might be expected. The west position, located closest to the disposal island, would be expected to have the highest values. Therefore, this is probably unrelated to the dredge and disposal operation.

Table 9. Mean Turbidity and Suspended Solids Values for the Three Locations on a Transect: East, Middle, and West.

Location	Turbidity (NTU)	Suspended Solids (mg/l)*
West	52	154
Middle	52	151
East	51	162

* Significant differences (α=.05) in analysis of variance between sampling site location on a transect.

In the analysis of variance, no significant difference in turbidity was found between the two sampling runs. Suspended solids, however, showed a significant difference, being highest in the second run (Table 10). This trend was also evidenced in the upstream control samples and therefore is probably not related to the dredging operation. Sampling between runs 1 and 2 was delayed one-half hour to allow for the passage of two barges. The passage of these two barges may have influenced ambient water quality or there may have simply been a natural flux in ambient levels.

Table 10. Mean Turbidity and Suspended Solids Values for the Two Sampling Runs

Sampling Run	Turbidity (NTU)	Suspended Solids (mg/l)*
Run 1	51	150
Run 2	51	161

* Significant difference (α=.05) in analysis of variance between sampling runs.

Comparison to Water Quality Standards. The Minnesota Pollution Control Agency (MPCA) water quality standard of 25 NTU was exceeded in all samples, including upstream control samples. The MPCA standard of 30 mg/l suspended solids was also exceeded in all samples. Ambient river water was approximately double the turbidity standard and 5 times the suspended solids standards.

SUMMARY

On 30 August 1979, a hydraulic dredging operation, with disposal of the dredged material in a confined on-land area with an effluent return, was monitored in Pool 5 of the Upper Mississippi River.

The bottom sediments from the dredge cut were coarse, consisting primarily of medium-grained sand, with some gravel. The sediments, when mixed with ambient river water, showed a low to moderate turbidity and suspended solids generation potential and a rapid settling with time.

Turbidity ranged from 43 to 58 NTU and suspended solids ranged from 122 to 232 mg/l in all river samples. Ambient levels were approximately 10 times those recorded for another study conducted only 8 days prior to this study and located within 10 miles of the Below West Newton dredge cut. This indicates that there are dramatic daily fluctuations in suspended material.

The effluent pipe was acting as a point source for suspended material. Turbidity and suspended solids values were from 5 to 10 times greater in the effluent than in ambient river water.

The turbidity and suspended solids data were statistically analyzed by analysis of variance which considered three factors; distance up- and downstream of the dredge and disposal area, sampling site location on a transect, and sampling runs. Significant differences in turbidity and suspended solids were found with distances up- and downstream of the dredge and disposal area. Elevations over ambient turbidity and suspended solids levels were found 300 feet downstream of the hydraulic dredge, but by 1,000 feet downstream both parameters had returned to ambient levels. Elevations over ambient turbidity levels were also found within 400 feet of the effluent pipe, but by 800 feet the turbidity values were not substantially different from control levels. For suspended solids, there were no significant elevations in concentrations below the effluent pipe that were directly related to the disposal operation.

Turbidity showed no significant differences between the sampling runs, or the sampling site location on a transect. Suspended solids did show significant differences between sampling runs and among sampling site positions on a transect. The differences found among sampling site locations were unexpected and probably not directly related to the dredging operation. Similarly, the differences between sampling runs were probably not directly related to the dredging operation, but may have been due either to barge activity or natural fluctuations.

A comparison of the results to MPCA Water Quality Standards indicated that ambient water quality was already poor; turbidity and suspended solids exceeded standards in all samples, including upstream control samples.

CONCLUSIONS

From 27 to 30 August 1979, maintenance dredging was performed at the Below West Newton dredge site (Cairo mile 746.6) in Pool 5 of the Upper Mississippi River. On 30 August 1979, the indicator parameters (turbidity and suspended solids) were monitored to assess the changes in water quality caused by the dredge and the effluents from the confined on-land disposal area. Statistically significant differences in turbidity and suspended solids values with distance up- and downstream of the dredge and disposal operations were found. Elevations in turbidity and suspended solids over ambient levels were found 300 feet downstream of the dredge but not found 1,000 feet below the dredge.

The effluent pipe from the confined on-land disposal area acted as a point source of suspended material, showing turbidity and suspended solids values 5 to 10 times greater than ambient river water. However, suspended solids did not show any elevation below the effluent pipe, and turbidity was elevated only over control values within 800 feet of the effluent pipe. Generally, where elevations in this study were found they were minor, only approximately 6 percent of upstream control values. This would indicate that very rapid settling and dilution occurred near the dredge and disposal area.

Ambient levels of turbidity and suspended solids on the day of sampling were already high, being at least double the applicable Minnesota State water quality standards, and tended to mask the effects of the dredging and disposal operation. The dredging and disposal operation caused a further degradation of the existing high levels, but only slightly, and in a very localized area (within 1,000 feet).

ABOVE LAKE STREET BRIDGE (CAIRO MILE 850.3)
MONITORING OF WATER QUALITY CHANGES
RESULTING FROM CLAMSHELL DREDGING

OBJECTIVE

The objective of the study was to determine the areal extent and magnitude of turbidity and suspended solids changes resulting from a clamshell dredging operation conducted by the derrickbarge HAUSER.

METHODS

DESCRIPTION OF SAMPLING SITES

The Above Lake Street Bridge dredge site is located at approximate Cairo Mile 850.3 on the Mississippi River, about 0.4 mile upstream of the Lake Street Bridge. Based upon historical records of maintenance, this site has a dredging frequency of 61 percent, requiring maintenance dredging approximately 2 out of every 3 years. Historically, the average volume removed per dredging job is 33,200 cubic yards, with an average annual volume of 20,200 cubic yards.

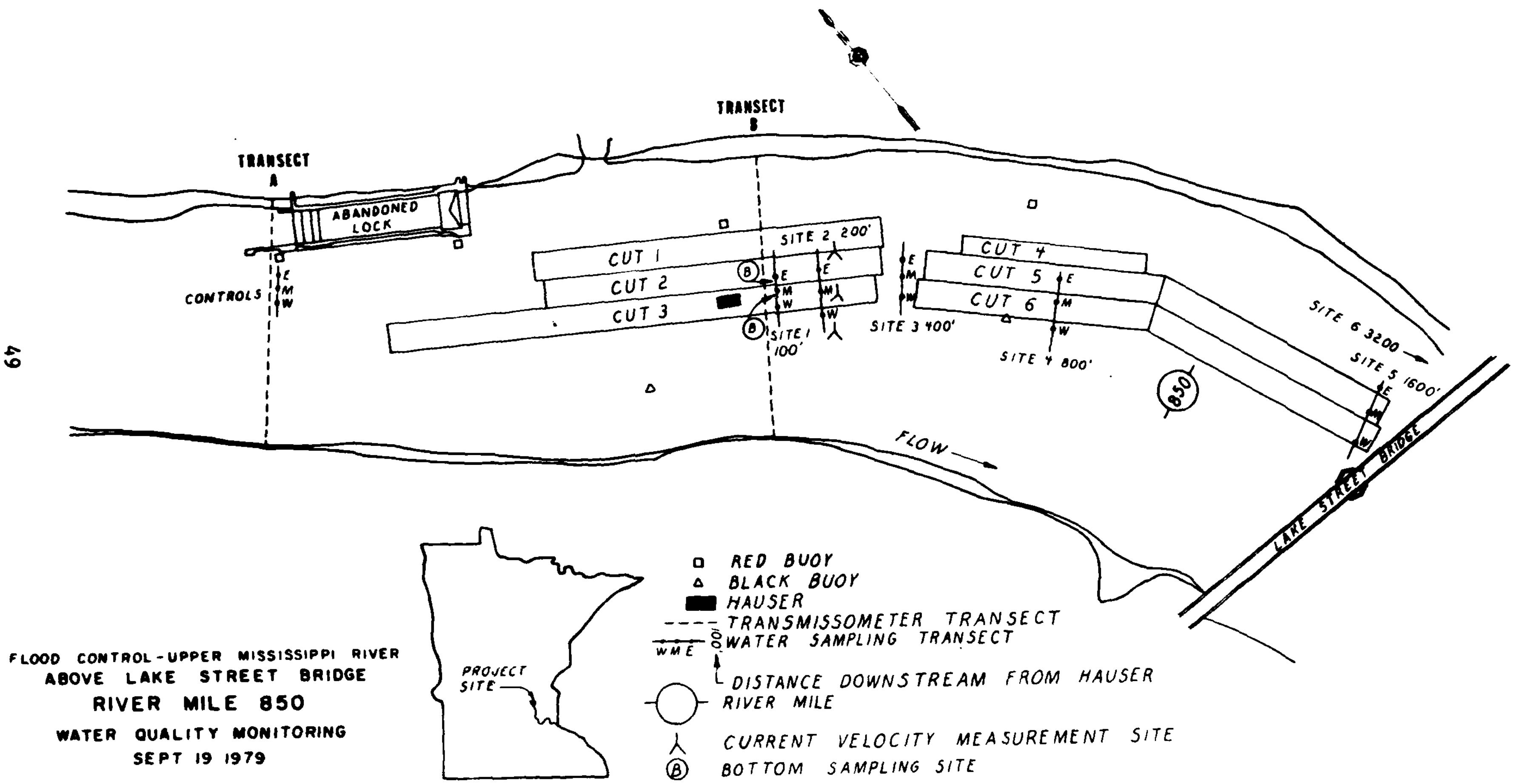
The 1979 dredging activity at the Above Lake Street Bridge dredge site involved the removal of approximately 29,704 cubic yards of material. All dredged material was barged upstream to the Minneapolis coal docks to be stockpiled for beneficial use. Dredging was accomplished by the derrickbarge HAUSER and its attendant vessels. Maintenance dredging commenced on 15 September 1979 and was completed on 1 October 1979.

EXPERIMENTAL DESIGN

Sediment. Prior to dredging operations, three sediment samples were collected with a Ponar bottom sampler from the area to be dredged (Figure 11). These bottom samples were used for particle size and settleability analysis.

Water. On 19 September 1979, discrete water samples were collected during dredging operations with the use of Van Dohrn and Kemmerer water samplers. A control site was located approximately 500 feet upstream from the derrickbarge HAUSER. Sample transects were located 100, 200, 400, 800, 1,700 and 3,200 feet downstream from the clamshell bucket of the HAUSER. Every sample transect had three sites, designated as east, middle, and west. The east and west locations were each approximately 50 feet from the middle site (Figure 11). At all sites, water samples were taken 3 feet from the bottom.

Figure 11. Above Lake Street Bridge Dredge Site on the Upper Mississippi: Sampling Site Locations (Sept. 19, 1979).



At each transect, samples were collected simultaneously from boats located in the east, middle, and west locations. Transects were sampled in order, beginning at the transect farthest upstream and moving downstream until all transects were sampled. This sampling schedule was repeated three times. A delay of approximately 45 minutes occurred between Runs 2 and 3 due to a shutdown of the HAUSER.

In addition to discrete water samples, a recording in situ transmissometer (Hydro Products Model 912) was used to measure the effects of the dredging operation on light transmission. The transmissometer was towed through the water at a depth of 6 feet along two cross-sectional transects. Transect A was an upstream control transect running from east to west. Transect B was located 100 feet downstream of the HAUSER, running from east to west. Transect B was run twice, with the second run going from west to east (Figure 11).

Current velocity measurements were also taken, using a Teledyne Gurley current meter, approximately 100 feet downstream of the HAUSER (Figure 11). Measurements were taken 1 foot from the bottom, at mid-depth, and 1 foot from the surface.

ANALYTICAL METHODS

Samples were chilled after collection and shipped as soon as possible for laboratory analysis. Particle size analysis of sediment samples was accomplished by the use of standard mesh screens and by hydrometer for finer particles. Settleability tests were conducted according to the methods described by Anderson et al., 1979. Analyses of the water samples were conducted according to methods set forth in the U.S. Environmental Protection Agency's "Methods for Chemical Analysis of Water and Wastes," July 1974.

St. Paul District, Corps of Engineers personnel collected the sediment samples and took the transmissometer readings. Environmental Protection Labs of St. Cloud, Minnesota, collected all water samples and conducted all laboratory analysis.

RESULTS

FIELD CONDITIONS

Weather conditions on 19 September 1979 were sunny and calm, with air temperatures of 75°F. Current measurements taken at two locations and at three depths--1 foot from the surface and bottom and at middepth--indicated that the current was rather slow on the day of sampling, having a mean velocity of only .52 feet/second.

Many storm sewers of the Twin Cities metropolitan area enter the Mississippi River in the area that was being dredged in Pool 1. However, on the day of sampling, none of the storm sewers in the immediate vicinity of the dredging operation were discharging.

Sampling was delayed at various points due to two operational shutdowns and one passing barge. An operational shutdown caused a 5-minute delay between sampling of transects 2 and 3 on run 2. An operational shutdown and a passing barge caused a 15-minute delay preceding the sampling of transect 2 on run 3. Other than the above-mentioned incidents, sampling was completed without disturbance.

SEDIMENTS

Particle Size. The bottom sediments from the area being dredged at the time of monitoring were mainly fine-grained sands (Appendix Table A1). Silts and clays contributed to only 3.4 percent of the total particle size distribution.

Settleability. Initial turbidity after 1 minute of settling had a mean value of 38.3 NTU from three samples (Appendix Table A2). Initial mean suspended solids concentration was 772 mg/l (Appendix Table A3). After 30 minutes of settling time, the settleability samples had a mean turbidity value of 25 NTU and a mean suspended solids concentration of 80 mg/l, indicating a rather rapid drop in suspended solids and a more gradual drop in turbidity values over time. Generally, these values are higher than those at many sites sampled on the Upper Mississippi in 1978 (Anderson et al., 1979). However, they are considerably lower than values at other sites sampled in the same study that had larger percentages of silts and clays.

WATER

Transmissibility. A recording in situ transmissometer was towed through the water 6 feet below the surface along two transects near the dredging operation (Figure 12). Transect A was a cross-section of the river upstream of the dredge. Transect B was run twice and was a cross-section of the river 100 feet downstream of the dredge. On Transect A, the percent transmission varied from 49 to 53.5 percent and had a mean value of 51.4 percent. In both runs on Transect B, the percent transmission varied from 40.5 to 57 percent transmission, with overall means of 51.0 in run 1 and 52.3 in run 2. Basically, there was very little difference in percent transmission between the two transects, indicating the clamshell dredge had no appreciable effect on the ability of the water to transmit light.

Discrete Water Samples. Discrete water samples were collected 3 feet from the bottom along transects located up- and downstream of the clamshell dredge. Turbidity values ranged from 4.7 to 6.0 NTU in all samples collected (Appendix Table A12). Suspended solids showed dramatic fluctuations and ranged from 2 to 40 mg/l in all of the samples. The turbidity and suspended solids data were statistically analyzed by a three-way analysis of variance. The three factors considered were distance up- and downstream of the dredge (-500, 100, 200, 400, 800, 1,600, and 3,200 feet), sampling site location on a transect (east, middle, west), and sampling run (runs 1, 2, and 3).

In the analysis of variance, significant differences for both turbidity and suspended solids were found with distance up- and downstream of the dredge. Elevations over upstream controls in both turbidity and suspended solids were observed down to 400 feet below the dredge (Table 11). Turbidity, 100 feet downstream of the dredge, showed a 10-percent increase (0.5 NTU) over upstream controls. Suspended solids, 100 feet downstream of the dredge, had a 75 percent increase (10 mg/l) over upstream controls. The effects on turbidity and suspended solids dissipated with increasing distance downstream of the dredge.

Table 11. Mean Turbidity and Suspended Solids Values for Transects Located Up- and Downstream of the Dredge.

Distance from Dredge (feet)	Mean Turbidity (NTU)*	Mean Suspended Solids (mg/l)*
-500 (controls)	5.1	12
100	5.6	22
200	5.4	19
400	5.3	19
800	5.2	14
1,600	5.1	14
3,200	4.9	17

* Significant difference in the analysis of variance (α=.05)

In the analysis of variance, location on a transect did not show any significant differences in turbidity values, but a significant difference was observed in suspended solids concentrations. The middle location had the highest mean value and the west location the lowest (Table 12). A possible explanation for this trend is that the middle boat used a 6-liter plastic Van Dohrn sampler and the two outside boats used 1-liter Kemmerer samplers. Therefore, it is possible that the differences observed may have occurred as a result of the two types of sampling devices used. Another possibility is that the middle location was more in the thalweg area, which probably has a greater suspended material transport capability. The control samples also exhibited this trend, making it difficult to determine how much effect the dredge may have had upon concentrations of suspended solids at the sampling site locations along the transects.

Table 12. Mean Turbidity and Suspended Solids Values for Sampling Site Locations on the Transects.

Locations	Mean Turbidity (NTU)	Mean Suspended Solids (mg/l)*
W	5.3	10
M	5.2	25
E	5.2	16

* Significant difference between locations (α=.05).

The analysis of variance also showed no significant differences among the three sampling runs. This would indicate that ambient water and the plume were generally uniform during the sampling period. However, it should be noted that individual sites showed wide fluctuations in values, indicating there may have been some short-term temporal and/or spacial variations in the plume.

Comparison to Water Quality Standards. In all cases, turbidity was well below the Minnesota Pollution Control Agency water quality standard of 25 NTU. The mean values for transects downstream of the dredge did not exceed the MPCA water quality standard of 30 mg/l suspended solids. However, 12 individual samples (including one in the controls) out of 63 possible cases had values exceeding the 30 mg/l standard. Eight of these 12 samples occurred in samples collected at the middle location, and may relate to the different sampling devices as discussed earlier.

SUMMARY

On 19 September 1979, a clamshell dredging operation was monitored to assess the changes in turbidity and suspended solids levels caused by dredging at a site in Pool 1 of the Upper Mississippi River.

Current velocities were rather slow on the day the water sampling was conducted, having a mean velocity of 0.52 feet/second.

The bottom sediments being dredged were predominantly fine-grained sands, with some silts and clays. The bottom sediments had a moderate turbidity and suspended solids generation potential and settling time.

Results from a recording in situ transmissometer indicated that use of the clamshell dredge had very little effect on the river water's ability to transmit light.

In discrete water samples collected up- and downstream of the dredging operation, turbidity values ranged from 4.8 to 6.0 NTU and suspended solids concentrations ranged from 2 to 34 mg/l.

The turbidity and suspended solids data were statistically analyzed by a three-way analysis of variance, which considered distance up- and downstream of the dredge, sampling site location on a transect, and sampling runs. Significant differences were found for distance from the dredge, with elevations over control levels occurring to a point 400 feet below the dredge. One hundred feet downstream of the dredge, a 10-percent (0.5 NTU) increase in turbidity and a 75-percent (10 mg/l) increase in suspended solids over upstream control levels occurred.

No significant differences were found for either turbidity or suspended solids between the three sampling runs, indicating that both ambient conditions and the dredge plume were fairly consistent within the sampling period. However, individual sampling sites had fluctuations in values, indicating that there may have been some short-term temporal and spacial variations.

Significant differences were found among sampling sites' locations on a transect with the middle sampling site showing the highest concentrations. However, because of a potential sampling bias and/or the unknown location of the middle sampling sites in relationship to the thalweg, it is impossible to draw many conclusions regarding this trend.

Turbidity was well below the MPCA water quality standard of 25 NTU in all samples. Mean values of suspended solids concentrations at various distances downstream of the dredge were below the MPCA water quality standard of 30 mg/l. However, several individual samples did have values exceeding 30 mg/l.

CONCLUSIONS

Maintenance dredging was conducted with the clamshell dredge HAUSER at the Above Lake Street Bridge dredge site, located in Pool 1 of the Upper Mississippi River, from 15 September 1979 to 1 October 1979. On 19 September 1979, the clamshell dredging operation at this site was monitored for turbidity and suspended solids changes in water quality. The clamshell dredge significantly increased turbidity and suspended solids concentrations downstream of the dredge. However, the elevations in turbidity and suspended solids values were relatively minor: 0.5 turbidity units and 10 mg/l suspended solids. In addition, these elevations dissipated with distance downstream of the dredge and by 800 feet were not substantially different from control values. Due to the localized and minor elevations noted in the indicator parameters (turbidity and suspended solids), it is unlikely that major degradation of water quality occurred with dredging at this site.

ISLAND 58 (CAIRO MILE 734.3)
MONITORING OF WATER QUALITY CHANGES
RESULTING FROM CLAMSHELL DREDGING

OBJECTIVE

The objective of the study was to determine the areal extent and magnitude of turbidity and suspended solids changes resulting from a clamshell dredging operation conducted by the derrickbarge HAUSER.

METHODS

DESCRIPTION OF SAMPLING SITES

The Island 58 dredge cut is located at approximate Cairo Mile 734.3 on the Mississippi River, approximately midway between Locks and Dam 5A and Locks and Dam 5. Based upon historical records of maintenance, this site has a dredging frequency of 57 percent, requiring maintenance slightly less than 2 out of 3 years. Historically, the average volume per dredging job is 47,800 cubic yards, with an average annual volume of 27,000 cubic yards.

The 1979 dredging activity at Island 58 dredge cut involved the removal of approximately 20,000 cubic yards of material. All dredged material was barged downstream to the Fountain City boat ramp parking lot. The material was then loaded onto Buffalo County Highway Department trucks and hauled to a beneficial-use stockpile site, to be used later by Buffalo County.

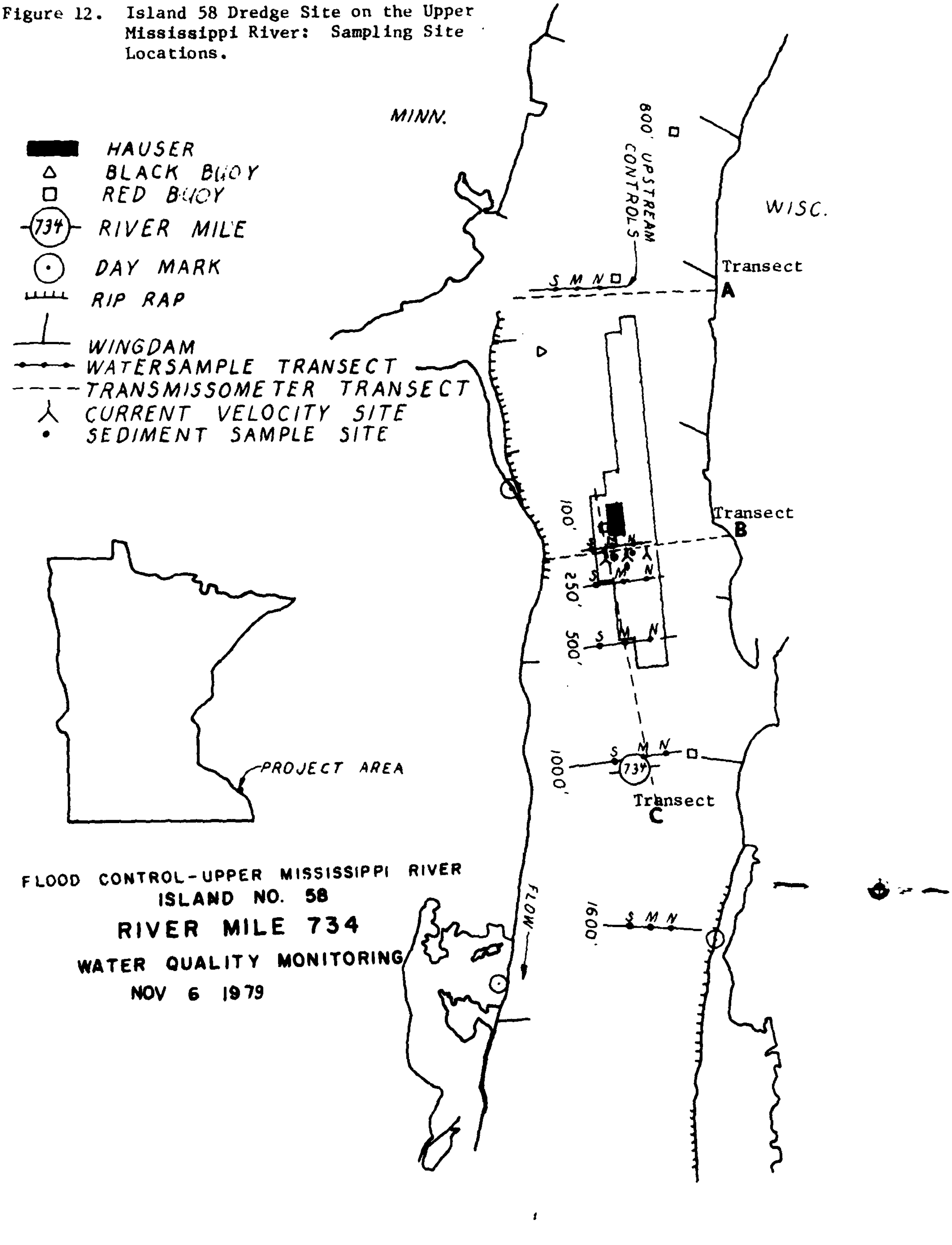
All dredging operations were conducted by the derrickbarge HAUSER and its attendant vessels. Maintenance dredging commenced on 30 October 1979 and was completed on 8 November 1979.

EXPERIMENTAL DESIGN

Sediment. Prior to dredging operations, three sediment samples were collected with a Ponar bottom sampler from the area to be dredged (Figure 12). These bottom samples were used for particle size and settleability analysis.

Water. On 6 November 1979 a recording in situ transmissometer (Hydro Products Model 912s) was used to measure the effect of the dredging operation on light transmission. The transmissometer was towed through the water at a depth of 7 feet along three transects (Figure 12). Transect A was an upstream control transect running north to south. Transect B was 100 feet downstream of the clamshell bucket and also ran north to south. Transect C ran upstream, starting about 1,200 feet downstream of the HAUSER and ending 200 feet upstream of the HAUSER.

Figure 12. Island 58 Dredge Site on the Upper Mississippi River: Sampling Site Locations.



Current velocity measurements were also taken, using a Teledyne Gurley current meter. A transect was established approximately 100 feet downstream of the HAUSER. Three sites (designated as north, middle, and south) along the transect were used for current measurement (Figure 12). At each site, readings were taken 1 foot from the bottom, at mid-depth, and 1 foot from the surface.

Discrete water samples were collected during dredging operations with the use of a Van Doarn water sampler. A control transect was located approximately 300 feet upstream of the HAUSER. Sample transects were located 100, 250, 500, 1,000, and 1,600 feet downstream of the Hauser (Figure 12). All transects ran roughly north to south. Each sample transect had three sample sites, designated as north, middle, and south. North and south locations were each approximately 50 feet from the middle location (Figure 12).

At all sample sites, water samples were taken at a depth of approximately 7 feet (in depth). At each transect samples were collected in sequence, moving south to north. Transects were sampled in order, starting with the transect farthest upstream and moving downstream until all transects were sampled. This sampling schedule was repeated three times.

ANALYTICAL METHODS

Samples were stored outdoors overnight. Air temperature was approximately 34°F; therefore, samples were not iced. Samples were picked up for analysis the morning following their collection.

Particle size analysis of sediment samples was accomplished by the use of standard mesh screens and by hydrometer for finer particles. Settleability tests were conducted according to the methods described by Anderson et al., 1979. Water samples were analyzed according to methods set forth in the U.S. Environmental Protection Agency's "Methods for Chemical Analysis of Water and Wastes," July 1974.

Corps of Engineers personnel collected all samples and obtained transmissometer and current velocity measurements. Environmental Protection Labs of St. Cloud, Minnesota, conducted all laboratory analyses.

RESULTS

FIELD CONDITIONS

Air temperature was approximately in the upper 30's to lower 40's°F. Water velocity was moderate, with an overall mean from three sampling sites and three depths (1 foot from surface and bottom and at middle) of 0.9 feet/second. Current velocity was slightly faster at middepth of the three depths sampled. One tow passed shortly before the completion of run 3, causing a slight delay.

SEDIMENT

Particle Size. Particle size analyses indicated that the sediments from the dredge cut were medium- to fine-grained sand (Appendix Table A1). Silts and clays were found only in trace amounts, 1 percent or less.

Settleability. Initial suspended solids concentrations in all three of the sediment samples were below 30 mg/l in each case (8 mg/l, 7 mg/l, and 10 mg/l). Therefore, further testing to determine settling over time was not done. The results indicate that the sediments had very little turbidity and suspended solids generation potential.

WATER QUALITY

Transmissibility. A recording in situ transmissometer was towed through the water at middepth along three transects near the dredging operation (Figure 12). Transect A, which was a cross-section of the river upstream of the dredging operation, showed results very similar to those at Transect B, which was a cross-section of the river 100 feet downstream of the dredge. Both transects showed the highest transmission readings near the Wisconsin shore, which had the greatest area of main channel border. The lowest readings came from the Minnesota side, where the main channel abuts the bank of an island. No observable differences caused by the clamshell operation were found.

Transect C, which ran from 1,200 feet downstream of the dredge to 200 feet upstream of the dredge and parallel to the current, showed a drop of 1-2 percent in transmission within 200 feet downstream of the dredge. Beyond 200 feet, the percent transmission returned to upstream levels. However, even this drop in percent transmission downstream of the dredge was well within the range recorded for Transect A, located upstream of the dredging operation.

Discrete Samples. Turbidity values ranged from 7.5 to 8.8 NTU in all of the samples collected (Appendix Table A13). Suspended solids ranged from 8 to 32 mg/l in all samples. The turbidity and suspended solids data were statistically analyzed by a three-way analysis of variance. The three factors considered were distance up- and downstream of the dredge (-800, 100, 250, 500, 1,000, and 1,600 feet), sampling site position on a transect (south, middle, and west) and collection runs (runs 1, 2, and 3).

In the analysis of variance, no significant differences were found for either turbidity or suspended solids with transect distance up- and downstream of the dredge. However, it does appear that, below the dredge, turbidity was up slightly but only by an average of 0.2 NTU. Suspended solids, however, decreased slightly (by 2.0 mg/l) below the dredge (Table 13).

Table 13. Mean Turbidity and Suspended Solids Values for Transects Located Up- and Downstream of the Clamshell Dredge.

Transect Distance Downstream of the Dredge	Mean Turbidity (NTU)	Mean Suspended Solids (mg/l)
-800 (upstream)	8.1	21.3
100	8.3	20.6
250	8.2	18.9
500	8.3	18.0
1,000	8.4	18.3
1,600	8.5	20.5

In the analysis of variance, turbidity showed no significant differences among the three runs, but significant differences were shown in suspended solids levels. Run 2 had the highest values and run 3 the lowest (Table 14). Since the controls also showed this same trend, this was probably caused by some factor other than dredging at this site.

Table 14. Mean Turbidity and Suspended Solids for the Three Sampling Runs.

Sampling Run	Mean Turbidity (NTU)	Mean Suspended Solids (mg/l)*
Run 1	8.3	19.0
Run 2	8.3	25.7
Run 3	8.3	13.2

* Significantly different in analysis of variance (α=.05).

In the analysis of variance, no significant differences were found with sampling site position on a transect. This would indicate that turbidity and suspended solids were fairly uniform in the main channel.

Comparison to Water Quality Standards. All samples in the study had turbidity values considerably lower than the Minnesota Pollution Control Agency (MPCA) water quality standard of 25 NTU. Suspended solids exceeded the MPCA water quality standard of 30 mg/l in 8 of 54 samples. However, they were equally distributed among upstream control samples and samples taken downstream of the dredge.

SUMMARY

On 6 November, a clamshell operation at Island 58, in Pool 5A of the Upper Mississippi River, was monitored for turbidity and suspended solids changes in water quality.

Current velocity was moderate, with a mean velocity of 0.9 feet/second on the 6 November 1979 sampling date.

Particle size and settleability analyses of the sediments from the dredge cut indicated that the material being dredged was coarse and had low turbidity and suspended solids generation potentials.

The effects of the clamshell dredging on the river water's ability to transmit light was monitored with a recording in situ transmissometer. The clamshell dredging operation did cause a slight decrease in light transmission (1.2 percent), but it was well within the range of values recorded from the control transect and the effects disappeared within 200 feet downstream of the dredge.

Discrete water samples were collected at middepth upstream and downstream of the dredge. Turbidity values ranged from 7.5 to 8.8 NTU and suspended solids ranged from 8 to 32 mg/l.

The turbidity and suspended solids data were statistically analyzed by three-way analysis of variance. The three factors considered were distance up- and downstream of the dredge, sampling site position on a transect, and collection runs. No significant differences were found for either sampling site position on a transect or distance up- and downstream of the dredge. A significant difference was found between the sampling runs, but this was also seen in the control samples and is probably attributable to some factor other than dredging at this site.

Turbidity values in all samples were well below the established Minnesota water quality standard of 25 NTU. The Minnesota water quality standard of 30 mg/l was exceeded in 8 of 54 samples. However, they were equally distributed among upstream control samples and samples taken downstream of the dredge.

CONCLUSIONS

From 30 October through 8 November 1979, maintenance dredging with the clamshell dredge HAUSER was performed at Island 58 (RM 734.3) in Pool 5A of the Upper Mississippi River. On 6 November 1979, indicator parameters (turbidity and suspended solids) were monitored to assess the changes in water quality caused by the clamshell dredge. No significant elevations attributable to dredging were found. The clamshell dredging operation at Island 58 did not appear to cause any degradation of water quality.

MONITORING OF EFFLUENT QUALITY FROM CONFINED ON-LAND DISPOSAL AREAS ON THE UPPER MISSISSIPPI RIVER FOR 1979

OBJECTIVE

In 1977, construction and development of bermed on-land containment areas were initiated as pilot studies at various locations along the Upper Mississippi River. These containment areas were constructed for two general purposes: (1) to restrain dredged material to the smallest area practicable to minimize physical impacts (burial) on wetlands and other aquatic habitat on the Upper Mississippi River, and (2) to maximize effluent quality and subsequently minimize water quality impacts of disposal of the dredged material.

This portion of the 1979 research addresses the latter purpose. The objective was to monitor effluent quality, as measured by turbidity and suspended solids from confined on-land disposal areas, in order to make a general prediction of water column effects and to assist in evaluating the efficacy of the pond areas in reducing water quality effects of the disposal of hydraulically dredged material.

METHODS

DESCRIPTION OF SAMPLING SITES

In 1979, seven dredging sites on the Upper Mississippi River were hydraulically dredged to maintain the 9-foot navigation channel. Dredging was accomplished at these sites with the 20-inch hydraulic dredge WILLIAM A. THOMPSON. In all cases, disposal of the dredged material occurred in confined on-land disposal areas, with a drop structure and culvert(s) to allow for the return of effluent. Pertinent information on the specific dredging and disposal operations is summarized in Table 15.

SAMPLE COLLECTION AND ANALYSIS

Water samples were collected by hand from the outlet end of the effluent pipe. In some cases where a flexible end was used on the effluent pipe, it was impossible to collect the samples directly from the pipe; therefore, they were collected near the inlet end of the pipe. All samples were chilled and sent to the laboratory for analysis. It should be noted that pH and conductivity were measured in the laboratory after aprroximately 2 days of shelf time. All laboratory analyses were performed by the U.S. Geological Survey Laboratory in Atlanta, Georgia, according to Skougstad et al., 1979.

RESULTS

EFFLUENT QUALITY

The Read's Landing dredging was conducted from 26 May to 15 June 1979. Effluents were generated from the disposal area on only 2 of the days of dredging, 8 and 9 June. Suspended solids (mg/l), turbidity (NTU), pH, and specific conductivity had mean values from the 2 days of sampling of 61, 28, 76, and 334, respectively (Appendix Table A14).

The Crats Island dredge cut was dredged from 16 June to 28 June 1979. Because of the large size of the disposal area and the coarse nature of the dredged

TABLE 15. SUMMARY OF HYDRAULIC DREDGING OPERATIONS ON THE UPPER MISSISSIPPI RIVER FOR 1979

POOL	MILE	DREDGE SITE	DATE OF DREDGING	EQUIPMENT	DEPTH (ft)	VOLUME DREDGED (c.y.)	PLACEMENT SITE	REMARKS
4	762.7	Reads Landing	26 May - 15 Jun	WAT*	12'	130,294	762.7 LB	Containment Area Seepage Problems
4	759.0	Crats Island	16 Jun - 28 Jun	WAT	12'	105,262	759.3 LB	Containment Area
5	745.5	Fisher Island	29 Jun - 11 Jul	WAT	13'	42,577	744.7 LB 745.7 RB	Lost Is. 19,889 berm failure Fisher Is. 22,688
6	837.0	St. Paul Barge Terminal	12 Jul - 6 Aug	WAT	13'	158,978	838.2 RB	Containment Area Beneficial Use
5	748.8	Mule Bend	7 Aug - 15 Aug	WAT	13'	35,155	748.7 RB	Containment Area
4	757.5	Above Teepeota Point	16 Aug - 25 Aug	WAT	13'	74,711	757.6 LB	Containment Area
5	746.6	Below West Newton	26 Aug - 31 Aug	WAT	13'	32,867	745.8 RB	Containment Area

*WAT = WILLIAM A. THOMPSON 20-inch Hydraulic Dredge material, which allowed seepage through the berms, no effluents were generated at this site.

The Fisher Island dredge cut was dredged from 29 June to 11 July 1979. Disposal of the material occurred in two containment areas. Initially, the dredged material was placed in the Lost Island disposal area (river mile 745.4) located along the left descending bank. No effluent pipe was used at this disposal site because it was felt that with the large disposal area available, sufficient seepage through the berm would occur. Unfortunately, sufficient seepage through the berm did not occur and a blowout of the berm occurred. The remainder of the material to be dredged was then placed in the Fisher Island disposal area (river mile 745.7) located on the right descending bank. Effluent was generated at the Fisher Island disposal area for 2 days. Mean values from the 2 days of sampling for suspended solids (mg/l), turbidity (NTU), pH, and specific conductivity were 60, 32, 7.8, and 406, respectively (Appendix Table A14).

At the St. Paul Barge Terminal historical dredge site, two dredge cuts were dredged from 7 July to 6 August 1979. Effluent generated from the disposal area was monitored for 10 days. The effluent data show dramatic differences between the two dredge cuts. Samples collected prior to 26 July 1979, when the first dredge cut was dredged, had generally much lower turbidity and suspended solids values than samples collected after 26 July 1979, when the second dredge cut was dredged. Samples collected when the first dredge cut was dredged had mean suspended solids (mg/l), turbidity (NTU), pH, and specific conductance of 316, 109, 7.4, and 577, respectively (Appendix Table A14). Samples collected when the second dredge cut was dredged had mean suspended solids (mg/l), turbidity (NTU), pH, and specific conductivity of 33,406, 1,027, 7.0, and 794, respectively. A possible reason for the dramatic differences is that the second dredge cut was located farther on the inside of the bend and closer to the river bank, and subsequently may have had finer bottom sediments.

Dredging at Mule Bend was conducted from 7 August to 15 August 1979. Effluent was generated for 3 days. However, due to problems within the laboratory, only one sample from the 3 days of effluent was analyzed. Suspended solids (mg/l), turbidity (NTU), pH, and specific conductivity had values from the 1 day of sampling of 61, 30, 8.1, and 402, respectively (Appendix Table A14).

Dredging at Teepeota Point was conducted from 16 August to 25 August 1979. Effluent was generated for 5 days at this site. Suspended solids (mg/l), pH, and specific conductivity had mean values from the 5 days of sampling of 64, 7.9, and 465, respectively (Appendix Table A14). Turbidity was not analyzed because of problems in the laboratory. It should be noted that prior to the Teepeota Point dredging job, major emphasis was placed on maximizing the retention time in the disposal area to create a better quality effluent. But at Teepeota Point and Below West Newton, because of the berm blowout at the Lost Island disposal area and the severe berm sloughing occurring at the Read's Landing disposal area, major emphasis was placed on preventing berm failure, and the retention time was reduced to approximately 2 hours.

Dredging at Below West Newton was initiated on 26 August 1979 and completed on 31 August 1979. Effluent was generated on all 5 days of dredging. The water samples collected at this site were lost, either in shipment or at the laboratory. Some data were obtained, however, because a turbidity and suspended solids study was conducted at the site (see pages 47 through 56). The one day of monitoring, 30 August 1979, had mean turbidity and suspended solids values of 633 NTU and 1,271 mg/l, respectively, from the effluent pipe (Appendix Table A11).

Effluents from the Read's Landing, Fisher Island, Mule Bend, and Teepeota Point disposal areas were generally similar in quality. Mean suspended solids concentrations and turbidity values in the effluents from these four sites ranged from 60 to 64 mg/l and 28 to 32 NTU, respectively (Appendix Table A14). At the Teepeota disposal area, water quality effects of the effluents from the disposal areas were also monitored (see pages 33 through 48). Because the effluents at the other three disposal areas were of similar quality, it is likely that generally similar water quality effects would be observed at these sites. However, hydraulic characteristics, influencing dilution and mixing and ambient levels may have also greatly influenced water quality effects at these three sites.

It is interesting to note that at the Read's Landing, Fisher Island, and Mule Bend sites, major emphasis was placed on ponding to increase retention time, and at the Teepeota Point site, major emphasis was placed on reducing ponding to prevent berm failure, yet the effluent quality was similar at the four sites. It appears that the coarse material settles out quickly in the disposal areas, but finer material remains in suspension due to the constant agitation of the material by the nearly continuous dredging operation. Unless quiescent or near-quiescent conditions can be established in the disposal areas, the effluent quality may not improve beyond a certain point. Quiescent or near-quiescent conditions are not likely to be achieved with existing disposal practices or size constraints of the disposal areas. However, an important point about ponding the water in the disposal areas is that it appears to reduce the number of days of effluent generation.

The effluents from the Below West Newton and St. Paul Barge Terminal sites were of much lower quality than the effluents from the other sites used in 1979. Water quality monitoring studies were conducted at both of these sites. Both studies indicated that the effluents caused only minor water quality effects (see earlier sections for further discussion). However, it should be noted that at the St. Paul Barge Terminal, effluent quality varied greatly, especially depending on whether the first or second dredge cut was dredged. Therefore, the water quality effects may have been greater or less than what was indicated by the monitoring study at the St. Paul Barge Terminal, depending on which day the studies were conducted.

Comparison to State Effluent Standards. In all samples collected from the six disposal areas, pH was well within MPCA effluent standards for the range of acceptable pH (WPC 15). Turbidity and suspended solids exceeded MPCA effluent standards of 25 NTU and 30 mg/l (WPC 15) in all samples collected from the six disposal areas that generated effluent.

SUMMARY

In 1979, seven dredging sites on the Upper Mississippi River were hydraulically dredged to maintain the 9-foot navigation channel. Disposal of the dredged material occurred in confined on-land disposal areas, with a drop structure and culvert(s) to allow for the return of effluent. At all but one of the seven sites, effluents were generated.

Effluents from the Read's Landing, Fisher Island, Mule Bend, and Teepeota Point disposal areas were generally similar in quality. Mean suspended solids concentrations and turbidity values in the effluents from these four sites ranged from 60 to 64 mg/l and 28 to 32 NTU, respectively. The effluents from the Below West Newton and St. Paul Barge Terminal sites were of lower quality than the other sites. The Below West Newton site had mean turbidity and suspended solids values in the effluent of 633 NTU and 1,271 mg/l, respectively. Two dredge cuts were dredged at the St. Paul Barge Terminal in 1979. Effluents generated when the first dredge cut was dredged had mean turbidity and suspended solids values of 109 NTU and 316 mg/l, respectively. Effluents generated when the second dredge cut was dredged had mean turbidity and suspended solids values of 1,027 NTU and 33,456 mg/l, respectively.

Attempts to maximize ponding and retention times within the disposal area reduced the number of days that effluents were generated. However, it would appear that because of the size constraints of the existing disposal area, a quiescent condition--which would allow for the setting of the finer material--cannot be achieved. Therefore, effluent quality may not improve beyond a certain point with existing dredging and disposal methods.

Values for pH in all effluent samples collected from the various disposal areas were within the range of applicable Minnesota State effluent standards. Turbidity and suspended solids exceeded Minnesota State effluent standards in all samples collected.

CONCLUSIONS

In 1977, bermed on-land containment areas for the disposal of dredged material were developed at various locations along the Upper Mississippi River, as pilot studies. The purposes of the containment areas were to restrain the dredged material to the smallest area practicable, and to maximize effluent quality and subsequently minimize water quality impacts of disposal of the dredged materials. In 1979, the effluents from these containment areas were monitored to assess the efficacy of these areas in reducing water quality effects of the disposal of dredged material. Ponding in these containment areas served to reduce the number of days of effluent generation. Effluents from the six sites dredged in 1979 that generated effluent contained pH levels within the range of Minnesota State effluent standards, but turbidity and suspended solids exceeded State effluent standards in all samples. The bermed containment areas probably served to improve effluent quality over the use of unrestrained disposal alternatives. However it appears that, given the size constraints of the available disposal areas and with continued use of present disposal methods, effluents from these containment areas will continue to exceed applicable effluent standards for turbidity and suspended solids.

1979 BOTTOM SEDIMENT RECONNAISSANCE

INTRODUCTION

During the 1979 maintenance dredging season, a bottom sediment reconnaissance was conducted for the navigation portions of the Upper Mississippi and Minnesota Rivers. The reconnaissance consisted of analyzing bottom sediments from selected dredge sites for both physical and chemical parameters.

When bottom sediment sampling was conducted prior to 1979, some sites in the St. Paul District could not be sampled, particularly those of low dredging frequency. Data were therefore not available for several sites in the District. The objective of the 1979 reconnaissance was to provide up-to-date data for some of these dredge sites. Data on sediments obtained in this reconnaissance will be useful in the development of appropriate dredged material management plans.

METHODS

EXPERIMENTAL DESIGN

Sites were selected from a list of all historical sites in the District. Those sites for which no current data were available and which possessed a dredging frequency greater than 10 percent were given higher priority. In addition, small and commercial boat harbors were given a high priority. Sites selected ranged in location from Pool 3 to Pool 10 of the Mississippi, and one Minnesota River site was sampled (Table 16). Sites located upstream of L/D 2 at Hastings, Minnesota, on the Upper Mississippi River were not included in this reconnaissance effort.

In order to obtain a representative cross-section of the data for the site, samples of both fine and coarse sediments were taken from each selected dredge site. At each site, a small Ponar grab was used to locate the areas of fine and coarse material within the cut. Samples were then taken in each representative area. Where sediments were found to be uniform, samples were taken from the upper and lower areas of the dredge cut on a random basis.

Samples for analysis were collected with a modified 9-in. X 9-in. Ponar grab sampler (an unplated grab, painted with a special non-contaminating paint and fitted with a fine stainless steel screen). Samples were composites of two or three grabs taken from within a 10-foot (diameter) area of river bottom.

All sediment samples were analyzed for particle size, settleability, and bulk chemical constituents. Samples were chilled and shipped to the laboratory as soon after collection as possible.

Table 16. 1979 Bottom Sediment Reconnaissance on the Upper Mississippi and Minnesota Rivers

Name of Dredge Cut	Pool No.	River Mile	Dredging Frequency	Site Length
Above and Below Cargill	Mn. R.	13.2	25%	0.8 mile
Hastings Small Boat Harbor	3	813	-	-
Truedale Slough	3	808	22	1.6
Red Wing Commercial Boat Harbor	4	791	-	-
Red Wing Small Boat Harbor	4	791	-	-
Alma Small Boat Harbor	4	754	-	-
Lower Approach L/D 4	5	752	26	0.2
Mule Bend	5	749	26	1.0
Below West Newton	5	746	57	0.8
Lower Zumbro	5	744.2	57	0.6
Mt. Vernon Light	5	741.5	13	0.4
Fountain City	5A	733.5	22	0.5
Winona Small Boat Harbor	6	726	-	-
Winona Commercial Boat Harbor	6	726	-	-
Head of Richmond Island	7	712.7	13	0.3
Above & Below La Crosse Railroad Bridge	8	699.9	22	0.9
Jackson Island	10	644.3	26	1.0

ANALYTICAL METHODS

Particle Size. Particle size analysis was conducted on all bottom sediment samples by mechanical and hydrometer methods. The analyses were conducted by the U.S. Army Corps of Engineers, Missouri River Division Laboratory, Soils Testing Laboratory in Omaha, Nebraska, according to procedures described in ER 1110-1-8100.

Settleability. Settleability tests were conducted on all sediment samples by the U.S. Army Corps of Engineers, Missouri River Division Laboratory in Omaha, Nebraska. One-thousand ml slurries were prepared in a graduated cylinder by agitating a 20 percent solids and river water mixture for 10 minutes. The 4:1 ratio of water to soil was determined by the following computation:

$$VT = 1{,}000 \text{ ml} = \frac{Ww}{Gw} + \frac{Ws}{Gs}$$

Where VT = total volume
Ww = weight of water
Gw = Sp. gravity of water
Ws = weight of soil
Gs = Sp. gravity of soil

For the above calculation, specific gravity tests were run as necessary to establish appropriate values for each sediment type.

Water samples were then withdrawn from the slurry with a suction bulb, at the following intervals: 0, 2, 4, 6, 24, 48, 96, and 192 hours or until a concentration of 30 mg/l suspended solids was attained. One 25 ml sample per time interval was withdrawn (5 cm below the surface) for both turbidity and suspended solids analyses.

Bulk Chemical Analysis. Bulk chemical analysis of sediments was conducted by the U.S. Geological Survey Laboratory in Atlanta, Georgia. The bulk chemical analyses were conducted according to methods described by Skougstad et al. (1979), and Goerlitz and Brown (1972).

RESULTS

GENERAL

A bottom sediment reconnaissance was also conducted during the 1978 dredging season (Anderson et al., 1979). The overall objective of the 1979 study was to provide current data to assist in the development of appropriate dredged material management plans.

In the ensuing presentation and discussion of the results, comparisons are made between the 2 years of sampling. However, some important differences exist between the 1978 and 1979 studies and are noted in the following discussion. Pools 1 and 2 were not sampled at all in the 1979 study. No boat harbors were sampled during the 1978 study. Some sections of the following discussion draw comparisons between the 1978 and 1979 studies (specifically, main channel sites in Pools 3 through 8). Boat harbors and Pools 1 and 2 are not included in the latter type of comparison.

CHLORINATED HYDROCARBONS AND OTHER BIOCIDES

Analysis for several different chlorinated hydrocarbons and other biocides was conducted on sediments in the 1979 study. Site specific data for the constituents discussed below can be found in Appendix Table A15.

Aldrin, chlordane, DDD, DDE, DDT, dieldrin, endosulfan, endrin, heptachlorepoxide, heptachlor, lindane, mirex, PCN, perthane, and toxaphene were all found to be below detection limits in all main channel sites in Pools 3 through 8 in both the 1978 and 1979 studies.

Chlordane, DDD, DDE, DDT, dieldrin, and polychlorinated biphenyls (PCB's) were detected in sediments from at least one site in 1979. These same parameters, plus endrin, were also found in at least one site in the 1978 study.

PCB's were the most prevalent contaminant, appearing in nine different sample locations in 1979. Of the nine sites where PCB's were found, six were boat harbors. The harbors also had the highest levels of PCB's, ranging from 13 ug/kg to 82 ug/kg. The remaining three sites, which consisted of main channel sites, did not exceed 3 ug/kg PCB's.

The harbors also accounted for all the pesticide constituents found in the 1979 bottom sediment study. No pesticides were found in any other sites sampled in 1979.

The Red Wing Small Boat Harbor was the only harbor that contained all five pesticides that were found in 1979. This harbor also had the highest detected levels for four of the five pesticides found in the study. It should be noted that the harbors, which have the most contaminants, also have the highest percentages of fine material. Barring the influence of the proximity of a point or non-point source of contaminants, it has been demonstrated that contaminants tend to associate with the finer sediments (GREAT I WQWG, 1978). This principle holds true for several other constituents to be discussed later.

METALS, NUTRIENTS AND MISCELLANEOUS

Site-specific data for the metal and nutrient constituents analyzed during the 1979 study can be found in Appendix A16. The reader should take note of the levels of NH_4 nitrogen found in this table. These levels are, in many cases, several times greater than those usually encountered on the UMR. The laboratory was contacted relative to this apparent discrepancy. Investigation disclosed an error in computation, rather than in the analysis. This computational error was subsequently corrected. Still, the levels of NH_4 nitrogen seem elevated. The reader should be mindful of this and should view the levels of NH_4 with caution.

Metals. Cyanide and mercury were not found above detection levels in any of the sites sampled in the 1979 study. Cyanide was not found below Pool 2 in the 1978 study. All samples from 1978 and 1979 contained less than 10 ug/g of cadmium. Arsenic was found in levels above zero in only four samples. Of the four sites in which arsenic was found, three were boat harbors. The range of arsenic levels, for all samples, was from 0 ug/g to 6 ug/g in 1979. Arsenic was not detected below Pool 2 in 1978.

In 1979, chromium values ranged from less than 10 ug/g to 60 ug/g. Only four samples in 1979 had chromium levels of greater than 10 ug/g and all were from the boat harbor sites. Only two sites sampled below Pool 2 had chromium levels above 10 ug/g in 1978.

Copper was detected in levels above 10 ug/g in five sites in 1979. Of these five sites, four were boat harbors. Copper levels in 1979 ranged from less than 10 ug/g to 30 ug/g. No sites in the 1978 study below Pool 2 exceeded 10 ug/g for copper.

Six of the 27 sample sites in the 1979 study contained lead in excess of 10 ug/g. Five of these six sites were boat harbors and one was in the Minnesota River. Lead levels ranged from less than 10 ug/l to 60 ug/l. One of the mechanisms of lead entering the environment is from the internal combustion engine. Lead is carried by rain and meltwater, via storm sewers, to the aquatic environment. Powerboats can also introduce lead directly, as in boat harbors. These lead sources, plus fine sediment and little or no current, offer an explanation for elevated lead levels in several boat harbors.

Barium, iron, manganese, nickel, and zinc are ubiquitous; they were found in all the 1979 samples. Barium levels ranged from 20 ug/g to 170 ug/g. Nine of the 27 sites had barium levels greater than 30 ug/g. Iron levels ranged from 2,100 ug/g to 21,000 ug/g. Manganese levels ranged from 100 ug/g to 1,200 ug/g. Levels of zinc ranged from less than 10 ug/g to 110 ug/g. Barium, manganese, iron, and zinc are naturally occurring and relatively abundant on the Upper Mississippi River. All except zinc are relatively nontoxic to man and aquatic organisms. Manganese, iron, and zinc are essential trace nutrients (EPA, 1976). Nickel levels ranged from less than 10 ug/g to 20 ug/g. Seven of 27 sites had greater than 10 ug/g nickel. In 1978, sites below Pool 2 showed similar ranges for these five metal constituents.

Chemical Oxygen Demand (COD) and Residue Lost on Ignition (LOI). COD varied considerably in the 1979 study. Levels for COD ranged from 550 mg/kg to 180,000 mg/kg. All six boat harbors and one site in the Minnesota River had levels of COD greater than 20,000 mg/kg. All other sites had levels less than 10,000 mg/kg, all but three of which were below 4,000 mg/kg COD. In 1978, sites below Pool 2 ranged from 120 mg/kg to 15,000 mg/kg COD.

Levels for residue (LOI) ranged from 2,230 mg/kg to 93,700 mg/kg in 1979. Eight out of 27 sites had levels greater than 10,000 mg/kg.

Nutrients. Kjeldahl nitrogen levels for samples in the 1979 study ranged from 120 mg/kg to 9,700 mg/kg. The range in values was generally lower below Pool 2 in 1978, ranging from 22 mg/kg to 1,200 mg/kg. Generally, although some exceptions occurred, those sediments with higher percentages of fine material had higher levels of Kjeldahl nitrogen.

Total phosphorus concentrations ranged from 38 ug/g to 1,300 ug/g in 1979. All of the boat harbors and both sites in the Minnesota River had total phosphorus levels in excess of 400 ug/g. All sites in the Mississippi River main channel had levels less than 300 ug/g. Sites below Pool 2 in the 1978 study had total phosphorus levels ranging from 14 ug/g to 960 ug/g. In 1978, only five sites below Pool 2 (out of 35 total sites) had total phosphorus levels in excess of 300 ug/g.

PARTICLE SIZE

Particle size analysis showed that the sediment studies in 1979 differed considerably between Mississippi River main channel sites and the Minnesota River and boat harbor sites (Appendix Table A17). The samples from sites within the main channel of the Mississippi River were coarse and would be classified as almost totally sand. Higher percentages of fine material were found in all of the boat harbors and in the Minnesota River samples. These samples has a range of 12 percent to 98 percent fine material. Of all the Mississippi River main channel samples, only two were composed of greater than 5 percent fine material. These samples had a range of fine material composition from 1 percent to 13 percent.

For 1979, the samples with high percentages of fine material were also those with the highest levels of contaminants. Pesticides were found in detectable levels only in the boat harbor samples. The levels of PCB's were also higher in the boat harbors when compared to other sites in 1979.

None of the sediments studied in 1979 were composed of material in the gravel-size range. All sediments were composed of material less than 3/8-inch in size.

SETTLEABILITY

Results of settleability tests can be used to predict the levels of turbidity and suspended solids at the point of discharge of a hydraulic dredging operation. The maximum turbidity and suspended solids generation potential of a particular sediment can be approximated by the initial concentration after agitation of the sediment/ambient water mixture.

Turbidity and suspended solids exhibited similar trends in 1979. Turbidity and suspended solids initial levels ranged from 26 FTU to 18,400 FTU and 292 mg/l to 270,788 mg/l, respectively (Appendix Tables A18 and A19). Nine sites had initial turbidity values of greater than 1,200 FTU. All of these nine sites were composed of greater than 9 percent fine material, and eight of these sites were above 12 percent fines. Fourteen sites had initial turbidity levels of less than 90 FTU. All fourteen of these sites has 3 percent or less fine material.

Six sites had initial suspended solids levels of greater than 40,000 mg/l. Of these six sites, five were composed of greater than 25 percent fine material. Fourteen sites had initial values for suspended solids less than 1,000 mg/l. All of these fourteen sites had 3 percent or less fine material.

Thirteen sites had both initial turbidity levels less than 90 FTU and initial suspended solids levels less than 1,000 mg/l.

Samples followed a general trend toward high initial levels of turbidity and suspended solids with higher percentages of fine material, and correspondingly, lower initial levels of turbidity and suspended solids with low percentages of fine material.

SUMMARY OF FINDINGS - 1979

Pesticides and PCB's were found to be associated with fine sediments. Those samples, especially from the boat harbors, with high percentages of fine material had comparatively high levels of pesticides and PCB's.

Generally, boat harbors were found to be higher in concentrations of several metal constituents. Arsenic, chromium, copper, and lead were found more commonly in boat harbors than in other main channel samples.

Barium, iron, manganese, nickel, and zinc were found in all samples. Barium, iron, manganese, and zinc are naturally occurring metals, however.

High COD levels were associated with high concentrations of fine material. The seven sites with the highest percentages of fine material all exceeded 20,000 mg/l COD.

All sites sampled from the Mississippi River main channel had total phosphorus levels less than 300 ug/g. All other sites exceeded 400 ug/g.

Particle size analysis indicated that most sediment from the Mississippi River main channel would be classified as sand. Fine material was found in these samples only in low levels. The boat harbor sediments were considerably higher in percentages of fine material. The boat harbor sediments accounted for all the pesticides detected and had high levels of several other chemical parameters.

Initial turbidity and suspended solids levels in the settleability tests correspond well with the amount of fine material present. Nine sites, all with greater than 9-percent fine material, had initial turbidity levels greater than 1,200 FTU. Six sites, five of which were greater than 25 percent fine material, had initial suspended solids levels of more than 40,000 mg/l.

REFERENCES

Anderl, W.H. 1978. Minnesota Pollution Control Agency. Personal communication.

Anderson, D.D.; R.J. Whiting; and B. Jackson. 1979. "An Assessment of Water Quality Impacts of Maintenance Dredging on the Upper Mississippi River for 1978." U.S. Army Corps of Engineers, Army Engineer District, St. Paul.

Claflin, T.O. 1976. "Resuspension of Sediments due to Hydraulic Dredging, Silt Screen, Polymers." Mimeographed Report to St. Paul District, U.S. Army Corps of Engineers, St. Paul, Minnesota.

Goerlitz, D.F., and E. Brown. 1972. "Methods for Analysis of Organic Substances in Water." Chapter A3, Book 5. United States Government Printing Office, Washington, D.C.

Great River Environmental Action Team I - Water Quality Work Group. 1978a. "A Pilot Study on Effects of Hydraulic Dredging and Disposal on Water Quality of the Upper Mississippi River (July 1976)." Published by the U.S. Army Corps of Engineers, St. Paul, Minnesota.

Great River Environmental Action Team I - Water Quality Work Group. 1978b. "Effects of Clamshell (Mechanical) Dredging and Disposal on Water Quality of the Upper Mississippi River." Published by U.S. Army Corps of Engineers, St. Paul, Minnesota.

Great River Environmental Action Team I - Water Quality Work Group. 1979. "Final Report to GREAT I Team."

Grimes, D.J. 1975. "Release of Sediment-bound Fecal Coliforms by Dredging." Applied Microbiology 29(1):109-111.

Held, J.W. 1978. "Environmental Impact of Dredged Material Disposal on the Upper Mississippi River at Crosby Slough." U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi. DMRP Miscellaneous Paper D-78-2.

Lee, G. Fred. 1977. "Corps of Engineers Criteria Project on Upper Mississippi River (Grey Cloud Slough Dredging Operation)." Mimeographed report to the U.S. Army Corps of Engineers Waterways Experiment Station. Institute for Environmental Sciences, University of Texas at Dallas.

Marking, L.L., and T.D. Bills. 1977. "Acute Effects of Silt and Sand Sedimentation on Freshwater Mussels." A study conducted for the St. Paul District, Corps of Engineers by the U.S. Fish and Wildlife Service, Fish Control Laboratory in La Crosse, Wisconsin.

McHenry, J.R., and Ritchie, J.C. 1976. "Sedimentation of Fines in Pools and Backwater Lakes of Lock and Dam No. 4 through No. 10 on the Upper Mississippi River." Sedimentation Laboratory, Oxford, Mississippi. Contract report submitted to Great River Environmental Action Team (GREAT) I - Sediment Erosion Work Group.

Minnesota Pollution Control Agency. 1975a. "Investigation of the U.S.C.E. Dredging Operation on the Mississippi River at Richmond Island - August 1, 1975." Division of Water Quality, Section of Surface and Groundwaters. MPCA, Roseville, Minnesota.

Minnesota Pollution Control Agency. 1975b. "Investigation of the U.S.C.E. Dredging Operations on the Mississippi River at Grey Cloud Island - September 10, 1975." Division of Water Quality, Section of Surface and Groundwaters, MPCA, Roseville, Minnesota.

Minnesota Pollution Control Agency. 1978. "Minnesota Lakes and Streams." A Compilation of Analytical Data for 1970-1975. Volume 8, Two Parts.

Minnesota Pollution Control Agency. 1978. "Minnesota Lakes and Streams." A Compilation of Analytical Data for October 1975 - September 1977. Volume 1.

Peddicord, R., H. Tatem, A. Gibson, and S. Pedron. 1980. "Biological Assessment of Upper Mississippi River Sediments." U.S. Army Engineers Waterway Experiment Station, Vicksburg, Mississippi. Miscellaneous Paper EL-80.

Skougstad, M.W., M.J. Fishman, L.C. Friedman, D.E. Erdmann and S.J. Duncan (Editors). 1979. "Methods for Determination of Inorganic Substances in Water and Fluvial Sediments." Chapter A1, Book 5. United States Government Printing Office, Washington, D.C.

U.S. Army Corps of Engineers, Army Engineer District, St. Paul, Minnesota. 1973. "Final Environmental Impact Assessment of the Northern Section of the Upper Mississippi River - Pool 2." Prepared by North Star Research Institute, Minneapolis, Minnesota.

U.S. Army Corps of Engineers, Army Engineer District, St. Paul. 1974. "Final Environmental Impact Statement: Operation and Maintenance, 9-foot Navigation Channel, Upper Mississippi River, Head of Navigation to Guttenberg, Iowa." St. Paul, Minnesota. Two Volumes.

APPENDIX A: RAW DATA

APPENDIX TABLES

Table A17. 1979 Particle Size Analysis of Sediments from Selected Dredging Sites on the Upper Mississippi River.

Table A18. 1979 Settleability (as measured by Turbidity) of 4 to 1 Mixtures of Upper Mississippi River Water and Sediments from Selected Dredging Sites on the Upper Mississippi River.

Table A19. 1979 Settleability (as measured by Suspended Solids) of a 4 to 1 Mixture of Upper Mississippi River Water and Sediments from Selected Dredging Sites on the Upper Mississippi River.

Table A1. Particle Size Analysis of Sediments from the Five Dredging Sites Where Water Quality Monitoring Studies Were Conducted in 1979.

Dredging Site (River mile)	Sampling Site[1]	Grading Cumulative Percent Finer (U. S. Standard Sieve Sizes) Fines		Sands			Gravel
		200 mm	100mm	40 mm	10 mm	4 mm	1 inch
St. Paul Barge Terminal (R.M. 837.5)	#1	4	13	63	97	100	
	#2	2	8	90	100		
	#3	5	13	82	100		
	#4	6	16	73	96	98	100
Below West Newton[3] (R.M. 746.5)	#1	0	1	9	67	77	100
	#2	0	1	11	88	100	
	#3	0	1	9	87	98	100
Above Lake Street[3] (R.M. 850.2)	#1	3.4	6	52	95	100	
	#2	3.4	7	89	100		
	#3	3.3	8	90	98	100	
Island 58[4] (R.M. 734.2)	#1	1	2	42	99	100	
	#2	0	2	38	99	100	
	#3	0	2	46	100	100	
Teepeota Point (R.M. 757.8)	#1	1	3	46	96	100	
	#2	2	4	48	97	100	
	#3	1	2	50	99	100	
	#4	1	2	68	99	100	

1. These identification numbers correspond to location numbers in Tables A2 & A3.

2. Analysis performed by Barr Engineering Co., Minneapolis, MN.

3. Analysis performed by Brown Engineering Testing.

4. Analysis performed by Missouri River Division, Corps of Engineers, Omaha, Nebraska.

Table A2. Settleability (as Measured by Turbidity) of 4 to 1 Mixtures of Upper Mississippi River Water and Sediments from the Five Dredging Sites Where Water Quality Monitoring Studies Were Conducted in 1979.

		Turbidity (NTU)											
		Time After Agitation (Hours)											
Dredge Site	Sample Number[1]	0	1/4	1/2	3/4	1	1-1/2	2	4	8	24	48	72
St. Paul Barge Terminal[2]	1	300		300		250		200	150	60			
	2	400		400		275		200	175	65			
Below West Newton[2]	1	166	64	42		30	24						
	2	104	37	21		14	14						
	3	126	34	33		26	21						
Above Lake Street[3]	1	50	41	37	35	30							
	2	35	28	21									
	3	30	20	18									
Island 58[3]	1	8											
	2	7											
	3	10											
Teepeota Point[4]	1	82.5				30		25	23		17	11	
	2	20				12		9	8		12	6.2	5.5

[1]These identification numbers correspond to location numbers in Tables A1 and A3.

[2]Analysis conducted by Serco Laboratories, Inc., Roseville, Minnesota.

[3]Analysis conducted by Environmental Protection Lab, St. Cloud, Minnesota.

[4]Analysis conducted by Missouri River Division, Corps of Engineers, Omaha, Nebraska (values are in FTU).

Table A3. Settleability (as Measured by Suspended Solids) of 4 to 1 Mixtures of Upper Mississippi River Water and Sediments from the Five Dredging Sites Where Water Quality Monitoring Studies Were Conducted in 1979.

		Suspended Solids (mg/l)										
		Time (Hours)										
Dredge Site	Sample Number[1]	0	1/4	1/2	3/4	1	1-1/2	2	4	8	24	48
St. Paul Barge Terminal[2]	1	3,790		720		264		132	72	20		
	2	10,230		750		472		220	88	24		
Below West Newton[3]	1	636	184	128		48	32					
	2	316	124	76		16	15					
	3	456	104	92		37	68					
Above Lake Street[3]	1	904	204	172	150	134						
	2	632	136	44								
	3	780	104	24								
Teepeota Point[4]	1	740				100		80	140	44	0	
	2	260				156		130	220		196	200

[1]These identification numbers correspond to location numbers in Tables A1 and A2.

[2]Analysis conducted by Serco Laboratories Inc., Roseville, Minnesota.

[3]Analysis conducted by Environmental Protection Lab, St. Cloud, Minnesota.

[4]Analysis conducted by Missouri River Division, Corps of Engineers, Omaha, Nebraska.

Table A4. Turbidity and Suspended Solids Data from Samples Collected Before Dredging at the St. Paul Barge Terminal (BT) Dredge Site. Samples Collected By Corps of Engineers and Analyzed by USGS.

Site	Date	pH	Turbidity (NTU)	Suspended Solids mg/l
BT-1	3 July	7.8	25	76
BT-2	3 July	7.8	25	85
BT-3	5 July	7.8	20	73
BT-4	5 July	7.9	20	70
BT-5	6 July	7.8	25	76
BT-6	6 July	7.9	25	89
BT-7	10 July	7.8	15	57
BT-8	10 July	7.8	20	64
BT-9	16 July	7.9	25	84
BT-10	16 July	7.9	20	75

Table A5. Turbidity and Suspended Solids Data from Background Samples Collected After Dredging Operations at St. Paul Barge Terminal. Samples Collected by Corps of Engineers and Analyzed by Serco, Inc., 13 August 1979.

Site	Turbidity (NTU)	Suspended Solids (mg/l)	Site	Turbidity (NTU)	Suspended Solids (mg/l)
BKGD BT-1	42	136	BKGD BT-6	45	149
BKGD BT-2	40	128	BKGD BT-7	47	143
BKGD BT-3	40	117	BKGD BT-8	47	144
BKGD BT-4	42	128	BKGD BT-9	40	119
BKGD BT-5	45	154	BKGD BT-10	42	144

Table A6. Turbidity and Suspended Solids for Run #1 and Run #2 of Phase I of the Water Quality Monitoring at the St. Paul Barge Terminal Dredge Site. Samples Collected 26 July 1979 by Corps of Engineers and Analyzed by Serco, Inc.

		RUN #1		RUN #2	
Site		Turbidity (NTU)	Suspended Solids (mg/l)	Turbidity (NTU)	Suspended Solids (mg/l)
Loc. 11	E	38	124		
	ME	40	114		
	MW	50	136		
	W	75	308		
	EP-E	20,000*	220,000*		
	EP-W	20,000	200,000		
Loc. 12	E	30	73		
	ME	80	320		
	MW	40	126		
	W	30	86		
Loc. 13	E	75	280		
	ME	75	334		
	MW	70	244		
	W	55	198		
Loc. 14	E	60	218	45	168
	ME	70	224	40	121
	MW	75	264	62	194
	W	65	254	30	65
Loc. 15	E	45	160	55	206
	ME	53	158	45	128
	MW	70	384	57	170
	W	55	190	48	136
Loc. 16	E	93	568	60	218
	ME	52	178	53	176
	MW	55	208	55	186
	W	35	93	50	158
Loc. 17	E	65	240	53	176
	ME	40	124	50	160
	MW	45	150	50	164
	W	28	64	40	114

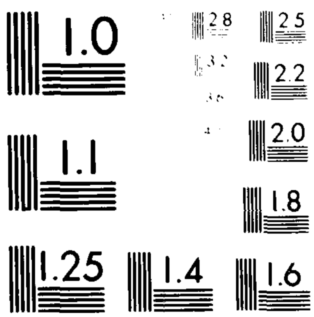
* Sample taken directly from effluent pipe.
Turbidity diluted 1:100 with de-ionized water.

AD-A109 983 CORPS OF ENGINEERS ST PAUL MN ST PAUL DISTRICT F/G 13/2
AN ASSESSMENT OF WATER QUALITY IMPACTS OF MAINTENANCE DREDGING --ETC(U)
OCT 81 D ANDERSON, R WHITING, J NOSEK

UNCLASSIFIED NL

2 OF 2

END
DATE
FILMED
02-82
DTIC



MICROCOPY RESOLUTION TEST CHART

Table A7. Monitoring of Selected Water Quality Parameters (Phase II) at the St. Paul Barge Terminal Dredge Site (25 July 1979).

SITE	CADMIUM	CHROMIUM	COPPER	LEAD	NICKEL	$NH_4 + NH_3$ (as N)	$NH_4 + NH_3$	ZINC	TURBITY(NTU)	SUSPENDED SOLIDS (mg/l)	DIELDRIN	PCB
1-E-A	1	13	8	12	9	0.01	0.01	40	50	178	0.00	0.0
1-E-B	1	12	6	12	9	0.00	0.00	30	50	182	0.00	0.0
1-E-C	5	12	6	12	7	0.01	0.01	30	50	162	0.00	0.0
1-W-A	0	13	4	4	8	0.01	0.01	20	52	164	0.00	0.0
1-W-B	0	8	6	3	8	0.08	0.10	20	48	144	0.00	0.0
1-W-C	0	21	3	3	8	0.01	0.01	40	50	160	0.00	0.0
2-E	11	15	28	55	22	1.5	1.8	90	200	872	0.01	0.0
2-W	1	27	36	66	29	0.02	0.02	180	200	864	0.00	0.1
3-E	0	10	6	14	9	0.06	0.07	20	47	149	0.00	0.0
3-W	2	21	24	41	18	0.99	1.2	90	172	615	0.00	0.1
4-E	1	12	4	12	10	0.06	0.07	20	53	156	0.00	0.0
4-W	1	9	17	23	15	0.73	0.88	50	125	452	0.00	0.0
5-E	8	12	5	14	11	--	--	30	55	174	0.00	0.0
5-W	0	14	3	13	10	0.01	0.01	30	45	122	0.00	0.0
6-E	0	9	4	11	12	0.04	0.05	10	50	164	0.00	0.0
6-W	1	16	7	16	12	0.06	0.07	40	65	204	0.00	0.0
7-E	0	15	7	17	11	0.04	0.05	50	51	174	0.00	0.0
7-W	0	16	9	7	8	0.24	0.29	40	-	-	0.00	0.0
7-A-E	0	16	4	12	11	0.02	0.02	40	45	144	0.00	0.0
7-A-W	0	6	6	3	7	0.04	0.05	30	73	225	0.00	0.0
8-E-A	0	18	4	10	12	0.03	0.04	30	50	146	0.00	0.0
8-E-B	0	14	4	11	10	0.02	0.02	20	53	164	0.00	0.0
8-W-A	0	16	6	3	8	0.11	0.13	30	50	148	0.00	0.0
8-W-B	2	5	7	4	13	0.05	0.06	30	55	184	0.00	0.0

* All values in microgram per liter(µ/L)a and are total cocentrations

Table A8. Results of In Situ Bioassay Conducted at the Teepeota Dredge Site.

Treatment: Distance (Feet) From Effluent Pipe	Exposure Time Survival of Fat Head Minnows (Pimephales spp.)			
	0 Hours	24 Hours	48 Hours	72 Hours
Control	50	49	49	39
100	50	50	48	46
400	50	50	50	44

Table A9. Turbidity and Suspended Solids Monitoring at the Teepeota Dredge Site (Analyses Performed by U.S. Geological Survey Laboratory, Atlanta, Georgia).

Sampling Site and Distance From Dredge or Disposal		Turbidity (NTU)		Suspended Solids (mg/1)		pH Laboratory		Conductivity	
		Run 1	Run 2	Run 1	Run 2	Run 1	Run 2	Run 1	Run 2
Con - E		4.0	4.0	22	25	7.8	8.0	441	415
Con - M		4.0	4.0	16	25	7.9	8.0	498	481
Con - W		4.0	4.0	16	24	7.9	8.0	534	520
1 - E	100	4.0	4.0	10	10	7.9	8.0	464	492
1 - M	100	4.0	4.0	10	10	7.8	8.0	450	487
1 - W	100	5.0	4.0	9	22	7.9	8.0	524	484
2 - E	1,000	4.0	4.0	18	14	7.9	8.0	416	401
2 - M	1,000	4.0	5.0	14	12	7.9	8.0	483	456
2 - W	1,000	4.0	5.0	16	9	7.9	8.0	505	513
3 - E	(100)	5.0	5.0	30	18	7.9	7.9	394	391
3 - M	(100)	7.0	5.0	32	16	7.9	7.9	396	392
3 - W	(100)	3.0	6.0	12	20	7.9	7.9	385	394
4 - E	(200)	5.0	6.0	22	19	7.9	7.9	393	391
4 - M	(200)	4.0	5.0	18	14	7.9	7.9	386	391
4 - W	(200)	3.0	4.0	16	16	7.9	7.9	385	386
5 - E	400	8.0	5.0	105	16	7.8	7.9	391	391
5 - M	400	4.0	5.0	27	14	7.9	7.9	387	385
5 - W	400	4.0	4.0	24	50	7.9	7.9	391	385
6 - E	1,600	4.0	9.0	22	124	8.0	7.9	388	391
6 - M	1,600	4.0	4.0	22	26	8.0	8.0	394	394
6 - W	1,600	4.0	3.0	22	17	8.0	8.0	410	398
7 - E	3,200	5.0	4.0	20	12	8.0	8.0	455	485
7 - M	3,200	4.0	4.0	18	13	8.0	8.0	487	525
7 - W	3,200	5.0	4.0	17	10	8.0	8.0	529	512

Table A10. Monitoring of Selected Water Quality Parameters at the Teepeota Dredge Site (Analyses Conducted by U.S. Geological Survey Laboratory, Atlanta, Georgia).

Sampling Site	Cadmium ug/l	Chromium ug/l	Copper ug/l	Lead ug/l	Nickel ug/l	(NH_3 + NH_4) mg/l	pH (LAB)	pH (FIELD)	Dis Oxygen mg/l	Residue Non Fil 105° mg/l	Sp. Conductance Lab	Temperature °C	Turbidity NTU	Zinc ug/l
Con-E-1	1	9	4	3	6	0.27*	7.8	8.2	8.5	22	441	22.0	4.0	10
Con-M-1	1	8	3	1	7	0.05	7.9	8.2	7.8	16	498	22.0	4.0	10
Con-W-1	7*	7	3	3	7	0.01	7.9	8.2	7.2	16	534	22.0	4.0	10
1-E-1	2	8	3	5	3	-	7.9	8.3	7.2	10	464	22.5	4.0	10
1-M-1	0	10	4	4	4	-	7.8	8.2	7.4	10	450	22.5	4.0	10
1-W-1	0	8	6	3	5	-	7.9	7.4	6.8	9	524	22.5	5.0	10
EP-1	2	10	6	6	13	0.13	7.8	8.2	7.7	63	480	24.0	30.0	30
EP-2	1	9	6	6	12	0.17	7.8	8.2	7.7	69	480	24.0	30.0	30
3-E-1	1	9	3	2	2	0.10	7.9	8.2	7.8	30	394	22.5	5.0	10
3-M-1	2	8	5	6	7	0.11	7.9	8.2	7.8	32	396	22.5	7.0	10
3-W-1	1	8	5	6	4	0.08	7.9	8.3	7.7	12	385	22.0	3.0	10
5-E-1	1	8	6	6	6	0.08	7.8	8.3	7.5	105*	391	22.5	8.0	20
5-M-1	1	8	4	3	6	0.10	7.9	8.2	7.8	27	387	22.0	4.0	10
5-W-1	1	8	4	5	5	0.12	7.9	8.2	7.9	24	391	22.0	4.0	10

*Outlier values not considered in discussion of the results or in statistical analyses.

Table All. Turbidity and Suspended Solids Data for Samples Collected at the Below West Newton Dredge Site (Analyses Conducted by Environmental Protection Laboratory, St. Cloud, Minnesota).

Sample Number and Transect Distance (feet) from Dredge (D) or Effluent Pipe (EP)	Turbidity (NTU)*			Total Suspended Solids (mg/l)		
	West	Middle	East	West	Middle	East
RUN #1						
1 Control	44	52	52	122	156	173
2 D 300	48	54	52	140	152	166
3 D 1,000	49.5	51	51	144	140	146
4 EP 200	54.5	55/53/54	51	148	154/174/160	163
5 EP 0	54.5	53	50	126	162	150
6 EP 100	52.5/52/52	54	53	146/156/152	144	165
7 EP 200	50	49	51	162	130	169
8 EP 400	53	48	50	120	130	143
9 EP 800	53	48	48	174	130	151
10 EP 1,600	52	46	57.5/52/52	126	144	150/156/159
11 EP 3,400	50	53	53	164	170	168
RUN #2						
1 Control	52.5	52	43	192	146	140
2 D 300	58	54	46	186	168	166
3 D 1,000	55	54/54/53	47	144	160/170/182	156
4 EP 200	49	52	54.5	162	152	166
5 EP 0	49/50/51	57	53.5	140/142/144	188	156
6 EP 100	73	53	51.5	270	148	168
7 EP 200	51	52.5	52	182	132	172
8 EP 400	56	53	52	180	142	180
9 EP 800	50	51	55/53/53	162	150	174/176/178
10 EP 1,600	50	46	52	232	138	162
11 EP 3,400	50	50	47	154	162	176
EFFLUENT PIPE #1						
1		690			1,150	
2		526			1,350	
3		714			1,300	
4		578/628/594			1,300/1,200/1,350	

* Triplicate analyses were run on approximately every tenth sample.

Table A12. Turbidity and Suspended Solids Data for Samples Collected at the Above Lake Street Dredge Site (Analyses Conducted by Environmental Protection Laboratory, St. Cloud, Minnesota).

Sample Number and Transect Distance (feet) from Dredge	Turbidity (NTU)			Total Suspended Solids (mg/l)		
	West	Middle	East	West	Middle	East
RUN #1						
1 Control	5.3	5.1	5.0	14	12	10
2 100	6.0	5.8	5.4	34	24	20
3 200	5.5	5.5	5.3	34	18	2
4 400	5.4	5.4	5.3	8	24	6
5 800	5.5	5.3	5.1	12	16	8
6 1,600	5.8/5.8/6.0	4.8	4.8	10/8/8	22	8
7 3,200	4.7	4.7	4.8	12	16	8
RUN # 2						
1 Control	5.2	5.0	5.2	10	17	8
2 100	5.4	5.3	5.3/5.5/5.4	9	30	16/18/12
3 200	5.4	5.1/5.2/5.3	5.4	2	30/34/34	26
4 400	5.3	5.4	5.3	8	40	32
5 800	5.3	5.2	5.1	8	34	8
6 1,600	5.1	5.1	5.0	12	30	8
7 3,200	5.0	4.9	5.0	4	30	30
RUN #3						
1 Control	5.2	5.2	5.1	2	32	6
2 100	5.6/5.7/5.7	5.6	5.6	4/6/6	28	28
3 200	5.5	5.6	5.3	6	22	28
4 400	5.4	5.4	5.1	8	26	20
5 800	5.1	5.3	5.0/4.9/4.9	6	20	18/14/22
6 1,600	5.0	5.2/5.3/5.2	5.3	4	34/34/22	6
7 3,200	5.1	5.0	5.0	2	28	24

Table A13. Turbidity and Suspended Solids Data for Samples Collected at the Island 58 Dredge Site (Analyses Conducted by Environmental Protection Laboratory, St. Cloud, Minnesota).

Sample Number and Transect Distance (feet) from Dredge	Turbidity (NTU)			Total Suspended Solids (mg/l)		
	West	Middle	East	West	Middle	East
RUN #1						
1 Control	8.1	8.0	8.0	26	16	32
2 100	8.3	8.2/8.4/8.5	8.0	28	11/10/12	22
3 250	8.0	8.6	8.5	18	16	12
4 500	8.3	8.6	8.4/8.3/8.3	22	24	7/9/9
5 1,000	8.3	8.5	8.6	20	14	16
6 1,600	8.4	8.6	8.6	20	18	20
RUN #2						
1 Control	8.2	8.1	8.0	20	30	30
2 100	8.3	8.7	8.0	20	32	28
3 250	8.0	8.3	8.0	22	30	26
4 500	8.4/8.0/8.3	8.4	8.3	17/14/17	30	24
5 1,000	8.5	8.6	8.0	14	26	32
6 1,600	8.5	8.7/8.6/8.4	8.3	32	24/22/26	26
RUN #3						
1 Control	8.2	8.0	8.3	18	8	12
2 100	8.5	7.9	8.5/8.6/8.6	20	12	12/12/12
3 250	8.6	8.2	7.9	18	12	16
4 500	8.3	8.0	7.5	10	14	16
5 1,000	8.4	8.3	8.4	12	28	18
6 1,600	8.5	8.4	8.4	12	16	16
BARGE SAMPLE		8.8			20	

Table A-14 Monitoring of Effluent Quality From Confined On-Land Disposal Areas for 1979

Dredge Cut or Disposal Area	Cairo Mile	Date Dredging Began	Date of First Effluent	# of Days of Effluent	Comments	Sample Date	Suspended Solids (110°C.) mg/l	Turbidity (NTU)	pH (Laboratory)	Sp. Conductivity (Laboratory)
Read's Landing	762.6	5-29	6-8	2	Samples Collected From Drop Structure	6-8	64	30	7.5	325
						6-14	57	25	7.7	342
Crat's Island	759.3	6-16	None	0	No Effluent					
Lost Island	745.4	6-29	None	0	Blow-out of Berm					
Fisher Island	745.7	7-2	7-10	2	Samples Collected Near Drop-Structure Inlet	7-10	62	30	7.8	404
						7-11	57	35	7.7	409
St. Paul Barge Terminal	837	7.70	7-20	11	Samples Collected From Drop Structure	7-20	446	150	7.3	446
						7-20	112	60	7.5	552
						7-23	215	90	7.5	626
						7-24	226	95	7.4	630
						7-25	581	150	7.3	631
						7-26	445	110	7.0	708
						7-27	86,000	*	7.0	892
						7-31	788	*	7.0	896
						8-1	11,400	1,300	7.0	629
						8-2	53,700	1,300	6.9	722
						8-3	48,100	1,400	6.9	918
Mule Bend	749.1	8-13	8-13	3	Samples Collected From Drop Structure	8-13	61	30	8.1	402
						8-14	*	*	*	*
						8-15	*	*	*	*
Teepeota Point	757.6	8-20	8-20	5	Samples Collected From Drop Structure	8-20	68	*	7.9	451
						8-21	61	*	7.8	483
						8-22	45	*	7.9	475
						8-23	68	*	7.9	468
						8-23	76	*	8.0	448

* Sample or parameter not tested because of problems in the laboratory.

Table A15. 1979 Bulk Chemical Analyses for Pesticides and Other Biocides of Sediments from Selected Dredging Sites on the Upper Mississippi River (Analyses Conducted by U.S. Geological Survey Laboratory, Atlanta, Georgia).

SITE NAME, RIVER MILE, DATE	ALDRIN ug/kg	CHLORDANE ug/kg	DDD ug/kg	DDE ug/kg	DDT ug/kg	DIELDRIN ug/kg	ENDOSULFAN ug/kg	ENDRIN ug/kg	HEPTACHEPOXIDE ug/kg	HEPTACHLOR ug/kg	LINDANE ug/kg	MIREX ug/kg	OIL & GREASE ug/kg	PCB ug/kg	PCN ug/kg	PERTHANE ug/kg	TOXAPHENE ug/kg
Ab. & Bel. Cargill 13.2-1 9-06-79	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	3	0	0.0	0
Ab. & Bel. Cargill 13.2-2 9-06-79	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	6	0	0.0	0
Hastings S.B. Harbor 813 8-30-79	0.0	8	4.9	4.6	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	74	0	0.0	0
Truedale Slough 808-1 8-30-79	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	3	0	0.0	0
Truedale Slough 808-2 8-30-79	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.0	0
Redwing C.B. Harbor 791-1 8-30-79	0.0	0	1.6	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	82	0	0.0	0
Redwing S.B. Harbor 791-2 8-30-79	0.0	9	4.2	5.3	1.2	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0	51	0	0.0	0
Alma S.B. Harbor 754 8-29-79	0.0	1	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	15	0	0.0	0
Lower App. L/D4 752 8-29-79	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	2	0	0.0	0
Mule Bend 749-1 8-29-79	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.0	0
Mule Bend 749-2 8-29-79	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.0	0
Bel. West Newton 746-1 8-29-79	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.0	0
Bel. West Newton 746-2 8-29-79	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.0	0
Lower Zumbro 744.2-1 8-29-79	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.0	0
Lower Zumbro 744.2-2 8-29-79	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.0	0
Mt. Vernon Lite 741.5-1 8-29-79	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	3	0	0.0	0
Mt. Vernon Lite 741.5-2 8-29-79	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.0	0
Fountain City 733.5-1 8-28-79	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.0	0
Fountain City 733.5-2 8-28-79	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.0	0
Winona S.B. Harbor 726-1 8-28-79	0.0	0	0.2	0.3	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100	19	0	0.0	0
Winona C.B. Harbor 726-2 8-28-79	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	13	0	0.0	0
Head Richmond Is. 712.7-1 8-28-79	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.0	0
Head Richmond Is. 712.7-2 8-28-79	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100	0	0	0.0	0
Ab. & Bel. LaCrosse RR Bridge 699.9-1 8-28-79	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.0	0
Ab. & Bel. LaCrosse RR Bridge 699.9-2 8-28-79	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100	0	0	0.0	0
Jackson Island 644.3-1 8-27-79	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100	0	0	0.0	0
Jackson Island 644.3-2 8-27-79	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.0	0

Table A16. Bulk Chemical Analyses for Metals and Nutrients of Sediments from Selected Dredging Sites on the Upper Mississippi River (Analyses Conducted by U.S. Geological Survey Laboratory, Atlanta, Georgia).

Site Name, River Mile, Date / Parameter	Arsenic ug/g	Barium ug/g	Cadmium ug/g	Chromium Tot ug/g	COD mg/kg	Copper ug/g	Cyanide ug/g	Iron ug/g	Lead ug/g	Manganese ug/g	Mercury ug/g	Kjeldahl Nitrogen mg/kg	NH4 Nitrogen ug/g	Nickel ug/g	Phosphorus Total ug/g	Residue (LOI) ms/kg	Zinc ug/g
Ab. & Bel. Cargill 13.2-1 9-06-79	0	80	<10	<10	29000	<10	0	9700	20	720	0.00	4100	48	20	510	30700	40
Ab. & Bel Cargill 13.2-2 9-06-79	0	40	<10	<10	8700	<10	0	3800	<10	160	0.00	1300	5.5	<10	400	5290	20
Hastings S.B. Harbor 813 8-30-79	2	110	<10	40	57000	30	0	11000	40	910	0.00	9700	109	20	1100	6090	90
Truedale Slough 808-1 8-30-79	0	30	<10	<10	3000	<10	0	5600	<10	580	0.00	5200	2.7	<10	290	74200	10
Truedale Slough 808-2 8-30-79	0	30	<10	<10	10000	20	0	4300	<10	260	0.00	1100	4.1	10	260	93700	20
Redwing C.B. Harbor 791-1 8-30-79	6	170	<10	60	99000	30	0	21000	50	1200	0.00	6800	166	20	1200	8790	110
Redwing S.B. Harbor 791-2 8-30-79	3	150	<10	40	180000	30	0	17000	60	1200	0.00	8400	36	20	1200	73400	100
Alma S.B. Harbor 754 8-29-79	0	70	<10	10	48000	10	0	12000	20	550	0.0	6300	40	20	1300	44300	40
Lower App. L/D4 752 8-29-79	0	20	<10	<10	970	<10	0	3300	<10	180	0.00	400	5.5	<10	190	5310	10
Mule Bend 749-1 8-29-79	0	30	<10	<10	1800	<10	0	3600	<10	260	0.00	300	6.2	10	230	4070	10
Mule Bend 749-2 8-29-79	0	30	<10	<10	3700	<10	0	2600	<10	150	0.00	300	4.3	<10	140	3980	10
Bel. West Newton 746-1 8-29-79	0	30	<10	<10	550	<10	0	2900	<10	190	0.00	300	3.1	<10	230	4740	10
Bel. West Newton 746-2 8-29-79	0	20	<10	<10	1000	<10	0	2800	<10	240	0.00	400	3.9	<10	170	3650	10
Lower Zumbro 744.2-1 8-29-79	0	20	<10	<10	1900	<10	0	2100	<10	100	0.00	300	5.2	<10	160	2280	<10
Lower Zumbro 744.2-2 8-29-79	0	30	<10	<10	1400	<10	0	2400	<10	100	0.00	500	4.4	<10	180	2230	10
Mt. Vernon Lite 741.5-1 8-29-79	0	40	<10	<10	2100	<10	0	2800	<10	200	0.00	300	6.9	<10	220	7310	10
Mt. Vernon Lite 741.5-2 8-29-79	0	30	<10	<10	7300	<10	0	3900	<10	290	0.00	2100	6.6	<10	200	13500	10
Fountain City 733.5-1 8-28-79	0	30	<10	<10	2100	<10	0	3200	<10	290	0.00	450	3.9	<10	180	5030	10
Fountain City 733.5-2 8-28-79	0	30	<10	<10	1300	<10	0	3700	<10	290	0.00	190	5.6	<10	200	3350	10
Winona S.B. Harbor 726-1 8-28-79	0	50	<10	<10	24000	<10	0	7000	20	340	0.00	3200	15	<10	460	29800	30
Winona C.B. Harbor 726-2 8-28-79	0	50	<10	<10	24000	<10	0	6400	<10	390	0.00	2900	36	<10	820	35200	20
Head Richmond Is. 712.7-1 8-28-79	0	20	<10	<10	1200	<10	0	3200	<10	150	0.00	320	6.1	<10	62	3050	<10
Head Richmond Is. 712.7-2 8-28-79	1	30	<10	<10	1700	<10	0	4600	<10	220	0.00	120	7.9	<10	170	4880	10
Ab. & Bel. LaCrosse RR 699.9-1 8-28-79	0	30	<10	<10	1300	<10	0	3500	<10	250	0.00	190	5.5	<10	220	4620	10
Ab. & Bel. LaCrosse RR 699.9-2 8-28-79	0	30	<10	<10	1000	<10	0	3600	<10	270	0.00	300	6.5	<10	280	5070	<10
Jackson Island 644.3-1 8-27-79	0	30	<10	<10	1900	<10	0	2700	<10	180	0.00	2300	5.8	<10	87	2800	<10
Jackson Island 644.3-2 8-27-79	0	20	<10	<10	1700	<10	0	2700	<10	190	0.00	8400	4.9	<10	38	2410	<10

Table A17. 1979 Particle Size Analyses of Sediments from Selected Dredging Sites on the Upper Mississippi River (Conducted by MRU, Omaha, Nebraska)

SEDIMENT CLASSIFICATION RECORD

GRADING (CUMULATIVE PERCENTS FINER)

SAMPLE SITE & RIVER MILE	HYD. ANALYSIS: FINES .005	HYD. ANALYSIS: FINES .02mm	U.S. STANDARD SIEVE SIZES: FINES 200mm	SAND 60	SAND 40	SAND 20	SAND 10	SAND 4	GRAVEL 3/8	GRAVEL 3/4	GRAVEL 1 1/2	GRAVEL 3 in.
Above and Below Cargill 13.2-1	19	33	46	80	100							
Above and Below Cargill 13.2-2	2	5	12	92	100							
Hastings Small Boat Harbor 813	10	22	37	40	53	67	97	99	100			
Truedale Slough 808-1	0	1	3	4	10	35	78	94	100			
Truedale Slough 808-2	0	0	2	2	13	65	98	100				
Redwing Commercial Boat Harbor 791-1	29	65	93	96	98	98	98	100				
Redwing Small Boat Harbor 791-2	20	60	98	99	99	99	100					
Alma Small Boat Harbor 754	7	26	56	63	90	100						
Lower Approach L/D4 752	0	1	1	2	15	70	96	100				
Mule Bend 749-1	0	1	2	3	21	72	94	99	100			
Mule Bend 749-2	0	0	1	2	53	91	99	100				
Below West Newton 746-1	0	0	1	2	13	55	79	96	100			
Below West Newton 746-2	0	0	1	1	37	91	100					
Lower Zumbro 744.2-1	0	2	3	18	93	100						
Lower Zumbro 744.2-2	0	2	2	11	96	100						
Mt. Vernon Light 741.5-1	1	2	2	3	33	78	96	100				
Mt. Vernon Light 741.5-2	0	1	5	10	69	89	97	100				
Fountain City 733.5-1	0	0	1	2	32	90	99	100				
Fountain City 733.5-2	0	1	1	2	32	80	94	97	100			
Winona Small Boat Harbor 726-1	5	13	19	35	91	100						
Winona Commercial Boat Harbor 726-2	6	14	26	36	63	83	92	96	100			
Head of Richmond Island 712.7-1	0	0	1	3	52	89	100					
Head of Richmond Island 712.7-2	0	0	1	2	16	61	90	99	100			
Above & Below LaCrosse RR Bridge 699.9-1	0	0	1	1	12	67	94	98	100			
Above & Below LaCrosse RR Bridge 699.9-2	0	0	1	2	16	78	98	100				
Jackson Island 644.3-1	2	6	13	35	98	100						
Jackson Island 644.3-2	0	0	1	8	92	100						

Table A18. 1979 Settleability (Turbidity) of a 4 to 1 Mixture of the Upper Mississippi River Water and Sediments from Selected Dredging Sites on the Upper Mississippi River (Conducted by MRD, Omaha, Nebraska)

Sample Sites/ River Mile	Turbidity (FTU) 0	1	2	4	24	48	72	96
Ab. & Bel. Cargill								
13.2-1	1200	110	70	62	29	15	9	
13.2-2	1700	115	46	42	21	15		
Hastings S.B. Harbor								
813	2600	290	250	150	53	45	15	
Truedale Slough 808-1	210	93	110	47	26	17		
808-2	41	27	19	18	15	9	10	
Redwing C.B. Harbor								
791-1	S A M P	L E	T O O	S M A	L L			
Redwing S.B. Harbor								
791-2	3500	1200	1700	1600	27	22	9	9
Alma S.B. Harbor								
754	3000	650	500	630	250	200		87
Lower App. L/D4								
752	41	27	18	17	17	9		10
Mule Bend								
749-1	42		17	15	13	9	7.4	
749-2	82	48	33	27	22	12	12	
Bel. West Newton								
746-1	34	19	15	12	11	6.5	6.7	
746-2	40	20	17	11	11	9	5	
Lower Zumbro								
744.2-1	60	38	34	25	19	15	10	
744.2-2	62	39	31	22	19	16	11	
Mt. Vernon Light								
741.5-1	660	122	98	84	33	24	16	
741.5-2	2000	360	230	170	62	41	26	
Fountain City								
733.5-1	26	18	15	12	10	8	7.9	
733.5-2	30	18	14	12	14	9	8.9	
Winona S.B. Harbor								
726-1	10400	1000	620	390	80	51	32	
Winona C.B. Harbor								
726-2	18400	480	290	205	44	35	24	
Head of Richmond Is.								
712.7-1	88	33	31	21	16	14	9	
712.7-2	28	15	12	10	11	8.6	7.9	
Ab. & Bel. LaCrosse RR Bridge 699.9-1	48	19	17	13	9	9.5	8.9	
699.9-2	34	18	13	12	11	9.5	8.1	
Jackson Island								
644.3-1	2050	200	140	80	24	19	12	
644.3-2	100	49	41	26	20	14	9	

Table A19. 1979 Settleability (Suspended Solids) of a 4 to 1 Mixture of the Upper Mississippi River Water and Sediments from Selected Dredging Sites on the Upper Mississippi River (Conducted by MRD, Omaha, Nebraska).

Sample Sites/ River Mile	Suspended Solids(mg/l) Hours After Agitation 0	1	2	4	24	48	72	96
Ab. & Bel. Cargill								
13.2-1	79880	224	140	192	60	40	0	
13.2-2	11396	196	112	180	64	0	0	
Hastings S.B. Harbor								
813	81436	660	392	708	116	32	76	
Truedale Slough								
808-1	780	344	824	204	56	0		
808-2	372	188	164	152	208	264	164	
Redwing C.B. Harbor								
791-1	SAMPLE TOO SMALL							
Redwing S.B. Harbor								
791-2	270788	189180	143272	82076	256	164	208	212
Alma S.B. Harbor								
754	41924	1872	1304	1044	300	196	220	220
Lower App. L/D4								
752	396	184	160	200	200	240		400
Mule Bend								
749-1	428	200	164	156	120	200	212	
749-2	700	212	208	264	248	216	192	
Bel. West Newton								
746-1	752			180	124	148	132	
746-2	428	216	160	252	104	320	376	
Lower Zumbro								
744.2-1	1024	204	176	232	72	128	116	
744.2-2	964	204	144	260	92	108	120	
Mt. Vernon Light								
741.5-1	3804	720	836	772	140	80	176	
741.5-2	13388	1060	908	968	380	144	172	
Fountain City								
733.5-1	292	252	244	112	204	180	204	
733.5-2	344	196	196	184	212	184	216	
Winona S.B. Harbor								
726-1	40516	1948	1380	952	636	172	184	
Winona C.B. Harbor								
726-2	73856	1036	968	916	168	140	200	
Head of Richmond Is.								
712.7-1	852	216	228	232	140	116	196	
712.7-2	296	224	260	168	164	224	252	
Ab. & Bel. LaCrosse RR Bridge								
699.9-1	308	176	176	160	208	292		
699.9-2	320	268	172	176	204	152	260	
Jackson Island								
644.3-1	4784	780	840	636	144	128	204	
644.3-2	1036	232	240	260	156	108	160	

FILMED

2-8